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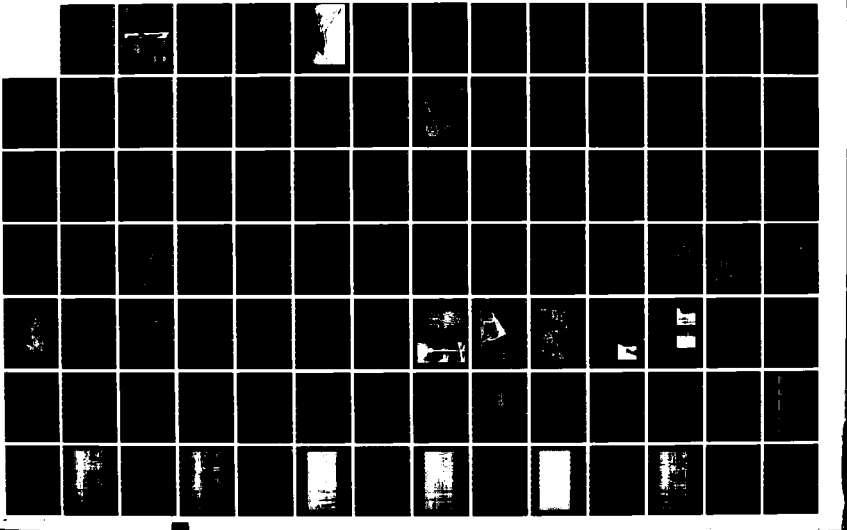

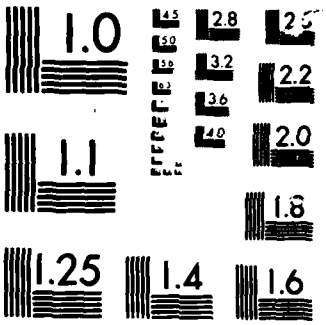
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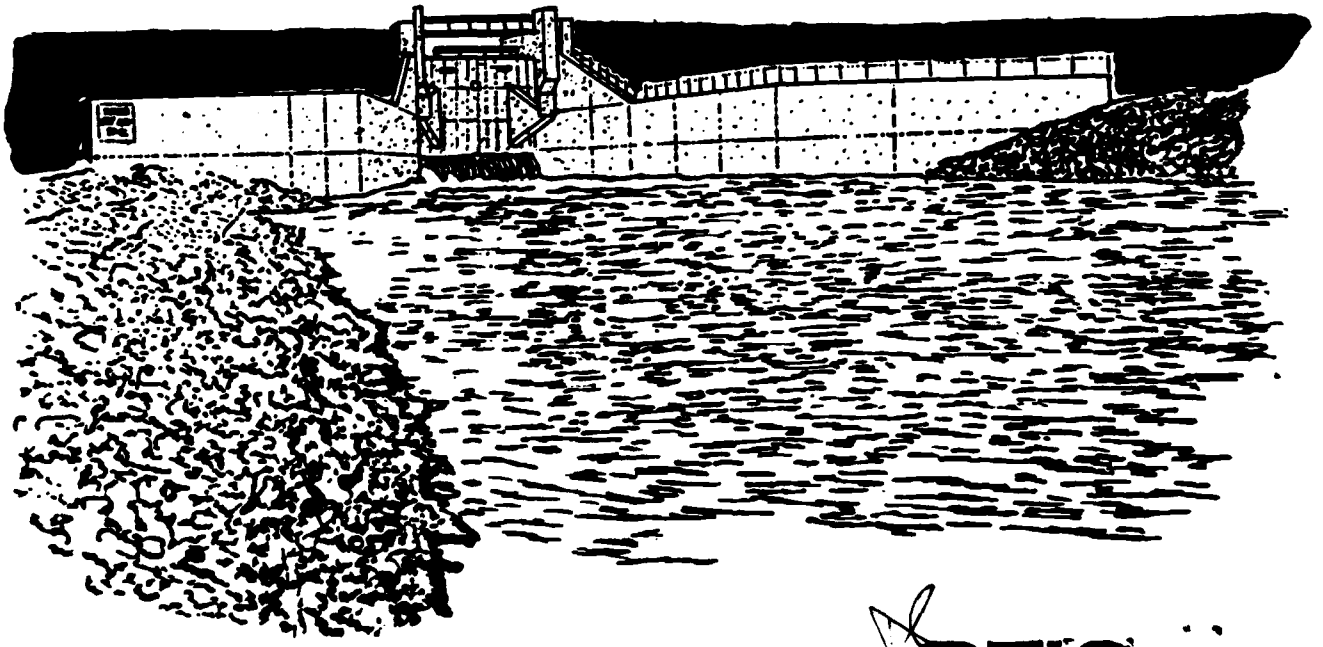
US Army Corps
of Engineers
St. Paul District

~~ORWELL RESERVOIR OPERATION PLAN EVALUATION AND ENVIRONMENTAL ASSESSMENT~~

FINAL ORWELL ROPE REPORT (RESERVOIR OPERATION PLAN EVALUATION) AND ENVIRONMENTAL ASSESSMENT



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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AOA 167896	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* FINAL ORWELL ROPE REPORT (RESERVOIR OPERATION PLAN EVALUATION) AND ENVIRONMENTAL ASSESSMENT.		5. TYPE OF REPORT & PERIOD COVERED FINAL
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)*		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. ARMY ENGINEER DISTRICT, ST PAUL 1135 USPO & Custom House St Paul, MN 55101-1479		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE January 1986
		13. NUMBER OF PAGES 195
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

FLOOD CONTROL
RESERVOIRS
RED RIVER OF THE NORTH
ORWELL DAM

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report presents the results of an evluation ofthe Orwell Reservoir operation plan and certain project features. The project has been in operation for over 30 years. During that time, changes have taken place in the area. This study is essentially a maintenance effort to ensure that this Federal project continues to provide maximum benefits.

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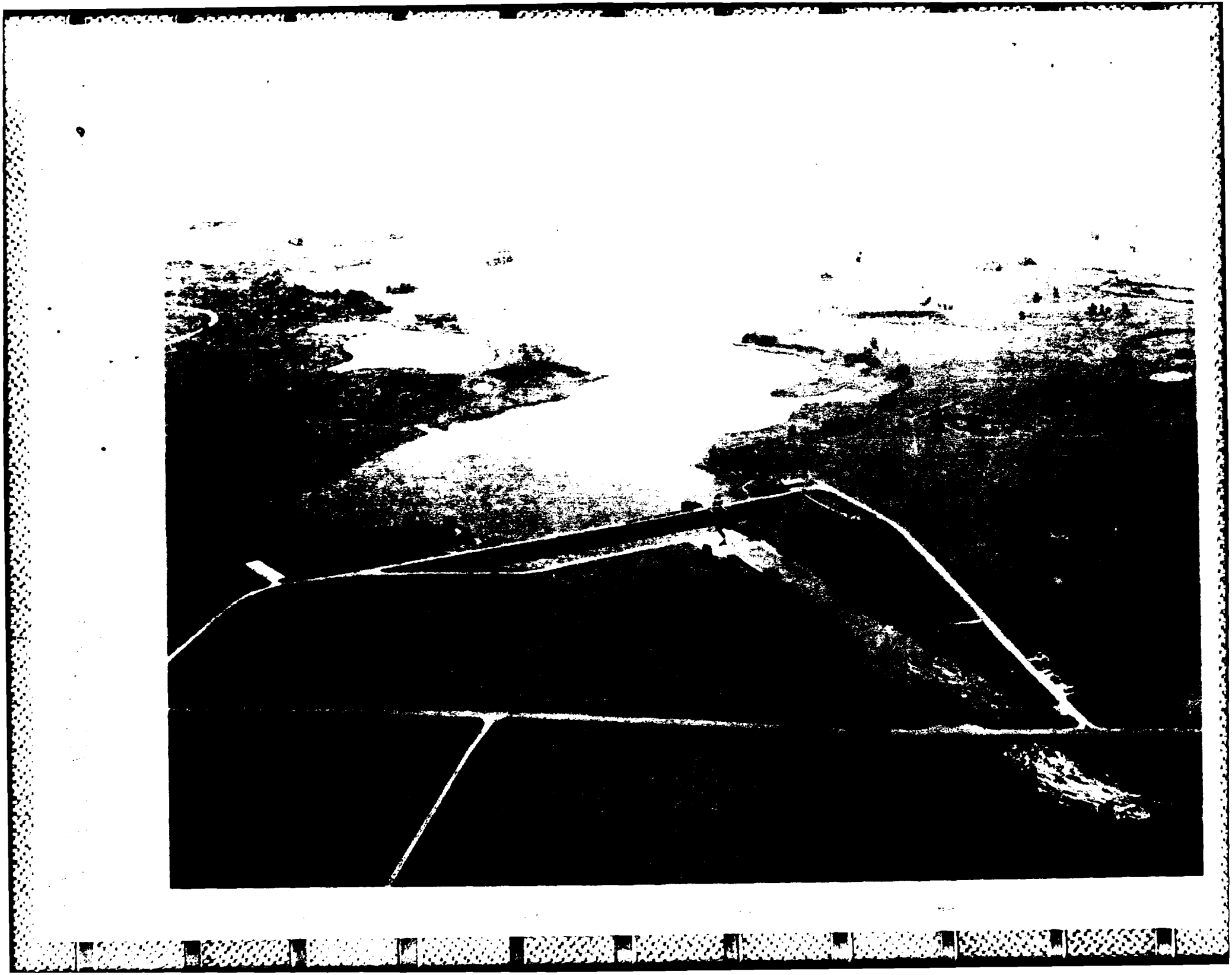
FINAL ORWELL ROPE REPORT
(RESERVOIR OPERATION PLAN EVALUATION)
AND ENVIRONMENTAL ASSESSMENT

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

January 1986



FINAL ORWELL ROPE REPORT
(RESERVOIR OPERATION PLAN EVALUATION)

EXECUTIVE SUMMARY

This report presents an evaluation of the existing reservoir operation plan and certain project features that affect the benefit-producing capability of the project. The plan formulation and evaluation were guided by the problems that were identified and summarized in the Problem Appraisal Report dated February 1985.

This report supports a number of recommendations that center on a recommendation to test a modified operation plan. The recommended operation plan would improve project contributions to the authorized purposes of flood control and pollution abatement, although the pollution abatement requirements in the basin have significantly reduced in scope since the project was authorized. Present needs for fish and wildlife, instream flow, shoreline stabilization, cultural resources, and recreation would be addressed by the recommended operation plan and supporting structural features. The recommended operation plan includes the following:

- Increase the assumed zero damage discharge to 1,200 cfs from 900 cfs to provide additional flexibility in operation for flood control.

- Lower normal full pool from elevation 1070 msl to 1068 msl.

- Reschedule pollution abatement releases from fall and winter to summer.

- Replace the two existing 24-inch low-flow outlet valves at a cost of $70,000 to eliminate a vibration problem that prevents the use of the existing valves.

- Provide continuous flow from the low-flow outlets during dewatering of the stilling basin for periodic inspections and maintenance activities. The flow will be provided with a temporary steel pipe extension of the low-flow conduit at a one-time cost of $10,000.

- Replace a failing 7-foot corrugated metal pipe (CMP) under County State Aid Highway 2 and add stoplogs to the culvert to control the subimpoundment behind the roadway embankment for waterfowl production at a total cost of $19,000. The CMP was originally installed by the Federal Government as part of the Orwell project.

The recommended reservoir operation plan, alternative 2, provides an increase of between $350,000 to $636,000 in average annual benefits over the existing operation plan, at no increase in annual operation and maintenance cost. In addition to the dollar benefits, plan 2 would:

- Increase low-density recreation opportunities.

- Increase the value of 195 acres of littoral zone in the reservoir and 200 acres in the subimpoundment for fish and wildlife habitat. Project lands are used for the Orwell Wildlife Management Area, a well-known MDNR waterfowl hunting area.

- Contribute to shoreline protection.

- Provide increased contributions to instream flow needs rescheduled to a more appropriate season.

ORWELL ROPE REPORT

(RESERVOIR OPERATION PLAN EVALUATION)

MEMBERS OF THE STUDY TEAM

The following people were members of the St. Paul District study team that produced this report.

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Paul Benkowski	725-7041	Real Estate
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Dave Berwick	725-7854	Cultural Resources
Ken Wrightsman	725-7592	Geotechnical
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Ed Eaton	725-7583	Water Control

FINAL ORWELL ROPE REPORT

(RESERVOIR OPERATION PLAN EVALUATION)

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

Tables

Tables (Continued)

Figures

Figures (Continued)

Plates

ORWELL ROPE REPORT
(RESERVOIR OPERATION PLAN EVALUATION)

REPORT PURPOSE

This report presents the results of an evaluation of the Orwell Reservoir operation plan and certain project features. The project has been in operation for over 30 years. During that time, changes have taken place in the project area. This study is essentially a maintenance effort to ensure that this Federal project continues to provide maximum benefits in light of current conditions.

PROJECT AUTHORIZATION

The Orwell Dam is part of a comprehensive plan for the Red River of the North basin authorized by Flood Control Acts approved on June 30, 1948, and May 17, 1950. The portion of the 1948 act that authorizes this project follows:

> The comprehensive plan for flood control and other purposes in the Red River of the North drainage basin, North Dakota, South Dakota, and Minnesota as set forth in the report of the Chief of Engineers dated May 24, 1948, is approved and there is hereby authorized the sum of $2,000,000 for the partial accomplishment of that plan.

Supplemental authorization is in the 1950 act:

> In addition to previous authorizations, there is hereby authorized the completion of the plan approved in the Flood Control Act of June 30, 1948, in accordance with the report of the Chief of Engineers contained in House Document Numbered 185, 81st Congress, for the Red River of the North Basin, at an estimated cost of $8,000,000.

Construction of the dam began in May 1951, and operation began in spring 1953. A contract for additional recreation facilities was completed in August 1971.

No local cooperation is required for the existing Orwell Dam project, including operation and maintenance.

PROJECT DESCRIPTION

LOCATION

Orwell Dam is in west-central Minnesota, in Otter Tail County, about 190 miles northwest of St. Paul and about 6 miles southwest of Fergus Falls, Minnesota. The dam is on the Ottertail River, 33 miles upstream of the point where the Ottertail and Bois de Sioux Rivers combine to form the Red River of the North. Plate 1 contains a project vicinity map and a basin map.

PRINCIPAL PROJECT FEATURES

The principal project features are the homogeneous rolled earthfill embankment, combined spillway and outlet structure, and two low perimeter dikes.

Embankment and Dikes

The embankment and two dikes were designed and constructed using a homogeneous section. The embankment has a cutoff trench (10-foot maximum depth) to minimize seepage through the upper sand and gravel foundation layer. A 3-foot-thick horizontal drain (pervious drainage blanket) intercepts any through seepage and underseepage. Slope protection includes 12- and 18-inch riprap. The top has a 6-inch stabilized aggregate surfacing. The embankment crest length is 1,355 feet, and the maximum height from embankment crest to toe is 47 feet.

Average height of the main embankment is 40 feet. The two dikes have a maximum height of 10 feet and a combined length of 1,140 feet. The embankment and structures are founded on glacial drift that overlies bedrock. The maximum pool elevation (spillway design flood) of 1075 feet above mean sea level (msl) will develop a head of 35 feet on the downstream toe of the embankment.

Embankment Foundation

The embankment is founded on a 2- to 10-foot-thick layer of pervious sand and gravel that overlies a 6-1/2- to 40-foot-thick layer of cohesive soils consisting of lean clay, silty clay, clayey silt, and silt, with some sand and gravel lenses. These formations are underlain by fine to medium sands of undetermined depth. The ground-water table in the upper pervious sand and gravel layer was found at or near the ground surface when preconstruction borings were done at the damsite. The same borings revealed artesian water in the underlying sands with sufficient pressure to raise the water to the ground surface. Materials at both abutments are primarily 25 to 30 feet of lean clays with some lenses of sand and gravel overlying 15 to 30 feet of clayey silts and silts. Fine to medium sands of undetermined depth underlie the clay and silt materials. The spillway and outlet structure are founded on 19 feet of dense, inorganic silt, and 7-1/2 feet of clayey soil, the latter extending to the sand layer, which is found at depths of 22 to 50 feet below the valley floor.

Spillway

The reinforced concrete spillway can be divided into five structural components: the upstream approach wingwalls, the ogee crest and abutment section, the trapezoidal chute, the trapezoidal stilling basin, and the downstream wingwalls. The ogee crest and abutment section is designed to act integrally as a rigid monolithic reinforced concrete gravity structure. Thickness of the ogee section varies from 9 to 17 feet, and thickness of the abutment is 8 feet minimum at the top.

Downstream of the area where the spillway begins to widen, the abutment tapers to less than 8 feet. Maximum abutment height is 50 feet. The chute and stilling basin sections are also monolithic structures having floor slabs with integral walls, but they are not designed as rigid structures. Floor width varies from 40 to 80 feet, and slab thickness varies from 4 to 6 feet, except for the transition to the ogee crest at the upstream end. The upstream approach and downstream wingwalls are inverted "T" cantilever retaining walls. Chute and stilling basin floor slab drainage are provided by a 6-inch gravel blanket under the slab and a system of 4-inch screened floor drain weepholes. Drainage for the wall section is provided by pervious backfill with filter gravel surrounding a perforated 8-inch P.V.C. drain system that discharges through the chute and stilling basin walls.

Tainter Gates

Spillway discharges are controlled by the single 33-foot-long and 27-1/2-foot-high welded structural carbon steel tainter gate. The tainter gate is electrically operated by means of duplicate, independent driving units on each abutment wall. An emergency generating unit provides power in the event of commercial power failure. A nine-section emergency bulkhead and a pickup boom are provided for emergency closure of the spillway. The bulkheads are fabricated of aluminum alloy to permit handling and installation by truck crane.

A potentially serious condition that developed during the first winter of operation involved an icing problem that froze the tainter gate in a partially opened position and resulted in loss of reservoir regulation. The condition was corrected in 1957 by installing a corrugated aluminum tainter gate housing connected to two L.P. gas-fired, forced hot-air heating systems.

Low-Flow Conduits

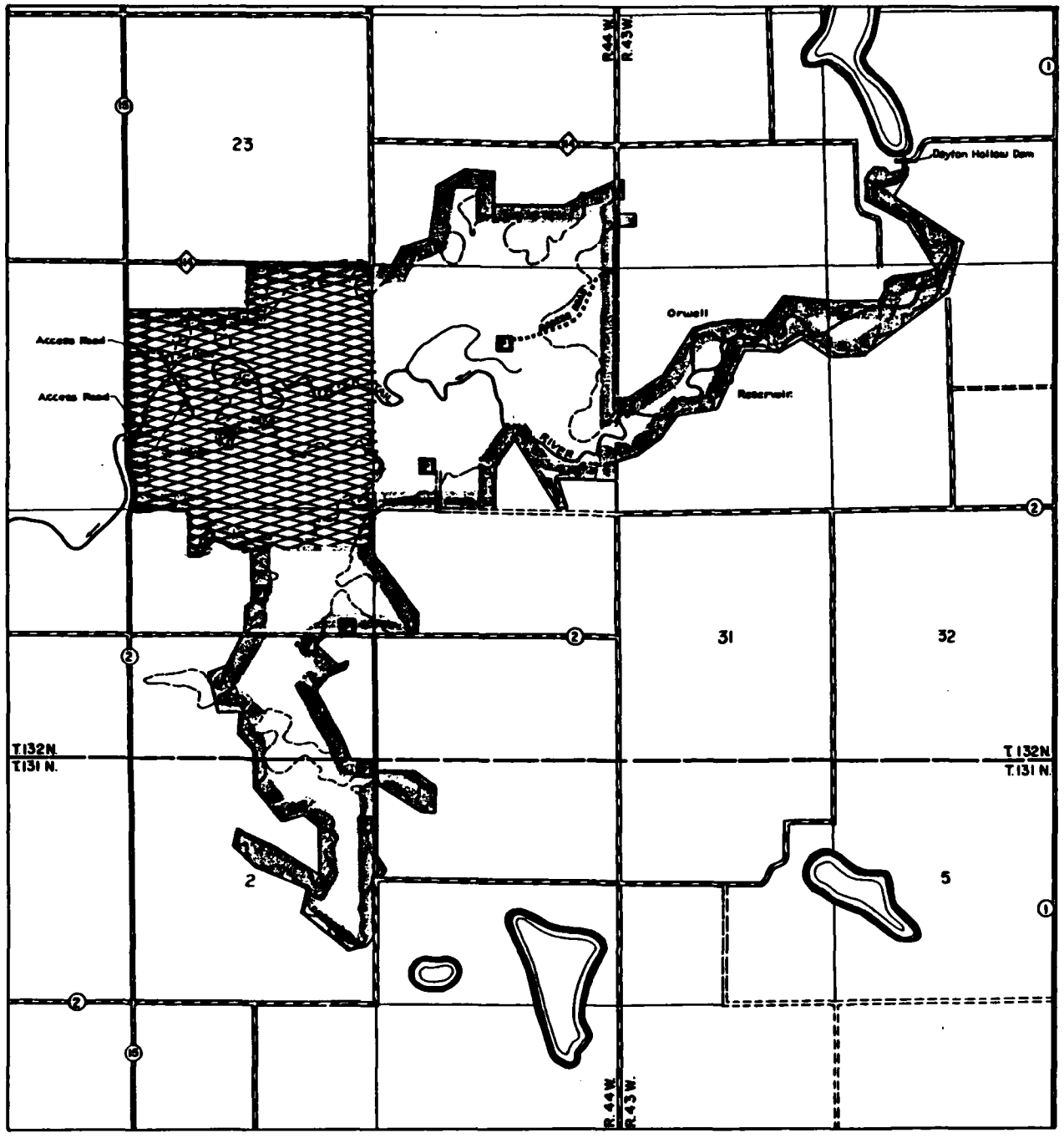
There are two 24-inch gated low-flow conduits in the ogee crest abutments. Flow through these conduits is controlled by 24-inch double-disk gate valves with inverts at elevation 1040.0 feet msl. Bulkhead recesses are provided in the intakes to the gate valves for emergency closure.

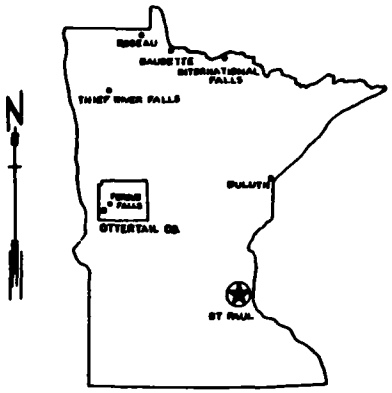
Downstream Channel Modification

In 1954 and 1955, the Ottertail River channel was cleaned, enlarged, and straightened by the Corps of Engineers between river miles 9.7 and 21.1. The design discharge of the channelization project is 900 cubic feet per second (cfs), plus freeboard. The channel modification has a design bottom width of 30 feet between miles 21.1 and 16.0, and 50 feet between miles 16.0 and 9.7. The material removed from the channel was placed in banks along the river no more than 8 feet high, and these banks are discontinuous at intersections with the old channel or natural watercourses to provide side drainage into the channel. The St. Paul District completed an operation and maintenance manual for the project in April 1960. The non-Federal sponsor and contact for the project is the Wilkin County Drainage and Conservancy District No. 1 in Breckenridge, Minnesota. The last periodic inspection found the project to be in good condition.

Project Lands

The Federal Government owns about 1,985 acres of land in connection with the project. About 1,957 acres of this project land are leased to the Minnesota Department of Natural Resources (MDNR) for wildlife management. The project area is known to the general public as the Orwell Wildlife Management Area. Figure 1 is an MDNR map of the wildlife management area, including a sanctuary. Figure 2 lists the general MDNR rules and regulations for use of the wildlife management and sanctuary areas.





LEGEND

- BOUNDARY OF WILDLIFE MANAGEMENT AREA
- BOUNDARY OF SANCTUARY
- COUNTY BOUNDARY
- HEADQUARTERS
- PARKING AREA
- UNITED STATES HIGHWAY
- STATE HIGHWAY SYSTEM
- COUNTY STATE AID HIGHWAY
- COUNTY ROAD
- TOWNSHIP ROADS AND OTHERS
- PRIMITIVE ROAD
- DITCH

NOTE: RULES AND REGULATIONS ARE LISTED ON REVERSE SIDE

MINNESOTA CONSERVATION DEPARTMENT

DIVISION OF GAME AND FISH

AREA MAP

ORWELL WILDLIFE MANAGEMENT AREA

OTTER TAIL CO. - NEAR FERGUS FALLS

SEC.	T. 131, 132 N	R. 43, 44 W	5TH P.M.
DRAWN G.H.R.	DIVISION OF WATERS ENGINEERS		SURVEY U.S. ARMY ENGINEER
CHECKED A.K.			
DATE 5-8-58	APPROVED		DATE
REVISED DAB 7-12-60			

REG. NO. 58-125 | SHEET 1 OF 1 | FILE G-417

FIGURE 1

STATE OF MINNESOTA
DIVISION OF GAME & FISH

REGULATIONS RELATING TO THE PUBLIC USE OF WILDLIFE MANAGEMENT AREAS.

No use shall be made of any state owned wildlife management area except in accordance with the following regulations:

Section 1. Entry and use.

(a) Those parts of wildlife management areas posted STATE GAME REFUGE - NO TRESPASSING, shall not be entered except as authorized by an agent of the Commissioner.

(b) No part of any wildlife management area may be entered or used during the hours 10 P.M. to 5 A.M. if so posted at the major access points.

Section 2. Hunting and trapping.

All wildlife management areas are open to the taking of wild animals by hunting or trapping during the established seasons therefor in the zones in which they are located unless specifically closed by Commissioner's Order. All persons shall report animals taken on wildlife management areas and submit them for inspection if requested to do so by an agent of the Commissioner.

Section 3. Fishing.

Taking of fish and minnows for commercial purposes is prohibited.

Section 4. Watercraft.

Use of motorized watercraft or amphibious vehicles is prohibited except as follows:

(a) In the Roseau River Wildlife Management Area, Roseau County, motorized watercraft may be used in the main channel of the Roseau River. Motorized watercraft powered by motors of 10 horsepower or less may be used elsewhere on this management area.

(b) In the Thief Lake Wildlife Management Area, Marshall County, motorized watercraft powered by motors of 10 horsepower or less may be used.

(c) In the Lac qui Parle Wildlife Management Area, Big Stone, Chippewa, Lac qui Parle and Swift Counties, and the Gores-Pool 3 Wildlife Management Area, Dakota and Goodhue Counties, motorized watercraft may be used except in those places posted by the Commissioner.

Section 5. Vehicles.

Motor vehicles may operate not in excess of 20 mph on roads and trails established for travel purposes. No person shall operate a snowmobile, all-terrain vehicle, motor bike, air boat or hover craft in a wildlife management area. Snowmobiles may be used on designated trails. Driving any vehicle anywhere except on established roads or trails is prohibited. No vehicle shall be parked where it obstruct travel.

Section 6. Aircraft.

Unauthorized use of aircraft below 1000 feet AGL (above ground level) over a wildlife management area is prohibited except in emergencies.

Section 7. Firearms and target shooting.

Target, trap, skeet or promiscuous shooting is prohibited.

Section 8. Disorderly conduct.

Obnoxious behavior or other disorderly conduct is prohibited.

Section 9. Disposal of waste and abandonment of property.

Disposal or abandonment of garbage, trash, spoil, sludge, rocks, cars and other debris or personal property on any wildlife management area is prohibited.

Section 10. Destruction or removal of property.

Signs, posts, fences, buildings, trees, shrubs, vines, plants or other property may not be destroyed or removed except that marsh vegetation may be used to build blinds and berries may be picked for personal use. Wild rice may not be harvested unless the area is specifically opened by Commissioner's Order.

Section 11. Private property or structures.

No person shall construct or maintain any building, dock, fence, beehive, billboard, sign or other structure on any wildlife management area. Deer stands may be built but shall not become private property or be used to preempt hunting rights.

Section 12. Private operations.

Soliciting business, agricultural cropping or conducting other commercial enterprises on any wildlife management area is prohibited except by lease agreement.

Section 13. Introduction of plants or animals.

Plant and animal life taken elsewhere shall not be released, placed or transplanted on any wildlife management area.

Section 14. Animal trespass.

Domestic animals shall not be permitted on wildlife management areas except as authorized by lease agreement. The use of dogs for hunting purposes is permitted.

Section 15. No person shall camp on any wildlife management area without permission of an agent of the commissioner.

FIGURE 2

A St. Paul District proposal to acquire approximately 30 additional acres of project lands to resolve a problem of shoreline erosion encroaching onto private lands is under review at the Corps of Engineers, North Central Division, in Chicago. Approval is required from the Office of the Chief of Engineers in Washington, D.C. Figure 6 (see page 29) is a map of the proposed acquisition area. The shoreline erosion problem is addressed separately in later sections.

Recreation

Day-use recreation facilities are located at the damsite. Hunting (waterfowl, white-tail deer, pheasant, ruffed grouse, and fox), sightseeing, nature study, and picnicking are among recreational opportunities available at the project. Road access and parking are provided near the dam. Some canoeing and inner-tube rafting occurs on the Ottertail River downstream from Orwell Dam.

OTTERTAIL BASIN DESCRIPTION

The Ottertail River rises north of Fergus Falls, Minnesota. The river flows south through a series of lakes until it reaches Otter Tail Lake, where it turns and flows west to its confluence with the Bois de Sioux River at Wahpeton, North Dakota. The basin contains more than 1,100 lakes, which cover more than 15 percent of the total basin area. An additional 6 percent of the basin is covered by swamps and marshes. The average slope of the river from Orwell Dam to Breckenridge is 3 feet per mile. Approximately 90 percent of the basin is used for agriculture, including grain crops (primarily wheat and corn) and livestock. Orwell Reservoir is on the edge of the former bed of glacial Lake Agassiz, in the transition zone composed of former beach ridges between the upland and lowland plains. Plate 1 contains a basin map.

At the U.S. Geological Survey (USGS) gage just below the dam, the Ottertail River has a drainage area of 1,830 square miles. Flow records are available from October 1930 to the current year, but only with

monthly discharge for some periods. From November 18, 1933, to March 21, 1953, the gage was located at a site 6.1 miles upstream and just below Dayton Hollow Dam. The maximum discharge was 1,710 cfs on June 17, 1953, and the minimum discharge was 0.70 cfs on August 5, 1970, as a result of regulation. Average discharge for 53 years was 304 cfs.

EXISTING PROJECT OPERATION AND RULE CURVE

Purpose of Operation

The primary objective in the existing operation of Orwell Reservoir is the reduction of damages caused by flooding in the lower reaches of the Ottertail River, especially at Wahpeton, North Dakota, and Breckenridge, Minnesota. Also, at times of deficient flow in the Red River, the water in storage in this reservoir may be used to supplement natural flows for instream flow requirements, water supply, and pollution abatement (waste assimilation). In addition to these primary objectives, the reservoir shall be used to assist in fish and wildlife management and production whenever possible.

Existing Regulation Schedule

The table and diagram on the following page contain general information about how the Orwell project is presently operated (1985) during routine flood control and low-flow conditions.

CURRENT ORWELL PROJECT CONDITION

A number of the project features have had problems corrected, but a number of problems remain. The following paragraphs describe the problems that have not been corrected.

US Army Corps of Engineers
St. Paul District

RULE CURVE

ORWELL DAM OPERATION PLAN

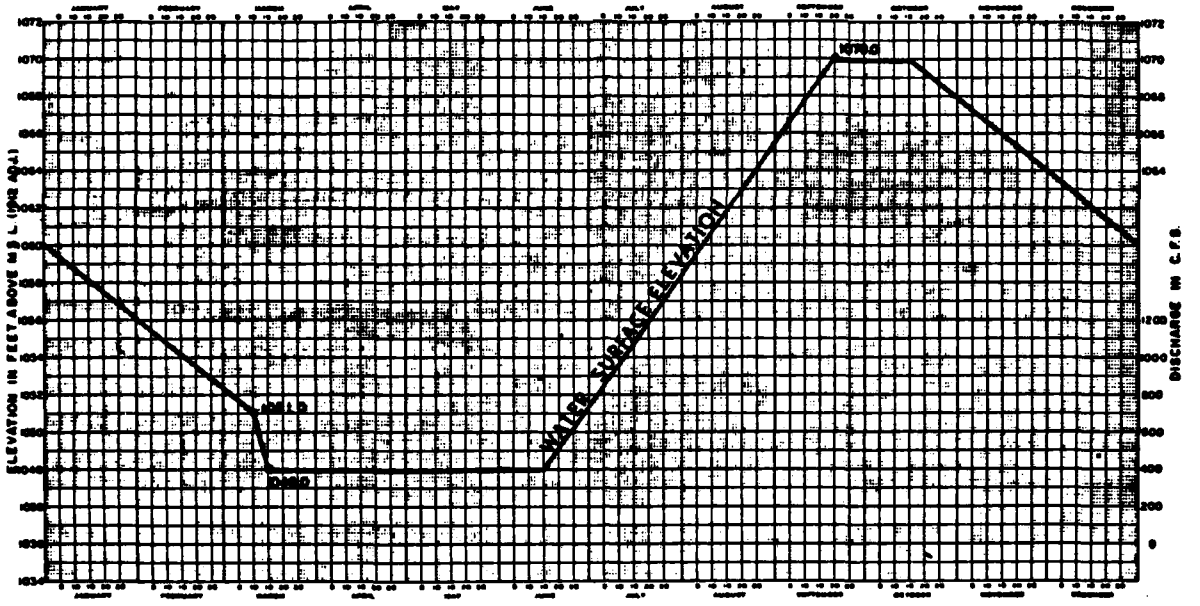


FIGURE 3

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freeseup to breakup	1070.0 to 1048.0	Normal	Beginning November 1 (freeseup), schedule winter releases to assure drawdown to elevation 1048.0, if necessary, by April 1. Coordinate with water requirements for sugar beet processing.
Breakup to about June 15	1048.0 to 1070.0	Normal runoff	During runoff period, allow reservoir to fill to elevation 1070.0. Discharge to bank-full capacity (900 cfs). Lower to 1048.0, if necessary. (See schedule plates 13 and 13A.) Do not aggravate flooding downstream.
June 15 to about September 20	1048.0 to 1070.0 or to elevation indicated by Reservoir Operator Curves, then fill to 1070.0.	Normal	Fill to elevation 1070.0 by September 20 in accordance with the Inflow-Recession and Flow Storage Filling Schedule Curves as shown on Plates 13 and 13A. If excess runoff occurs during period, fill to 1070 prior to September 20, if necessary. Maximum discharge will be bank-full capacity (900 cfs). After crest has been reached, revert to schedule prescribed above.
September 20 through December	1070.0-minus	Normal	Beginning about September 20 through December, release discharge for water supply, pollution abatement, and sugar beet processing. Minimum requirements, approximately 40 cfs.
Flood Control			
High water period	1048.0 to 1070.0+	Large runoff predicted	Fill to 1070.0 but when it becomes apparent prior to filling to elevation 1070.0 that induced surcharge will be necessary, discharge greater than bank-full capacity (presently 900 cfs) can be released to permit a more gradual increase in discharges after elevation 1070.0 is reached.
Induced surcharge	1070.0+	Pool continues to rise above 1070.0	Discharge 90 percent of reservoir inflow rate for previous 3-hour period. After maximum pool has been reached, maintain maximum gate opening until pool level drops to 1070.0.
Induced surcharge	1070.0-	Pool falling	When pool drops to 1070.0 revert to appropriate routine operation schedule.
Water Supply and Conservation*			
Low water period	1070.0 to 1048.0		Storage will be released if available to supply minimum requirements downstream. Minimum releases will not be less than 5 second-feet. Raising reservoir level to 1070.0 by September 20 may not be possible.

* Requirements for water supply and pollution abatement for the cities of Fargo, North Dakota, and Moorhead, Minnesota, must be supplied by Orwell Reservoir until such time as the proposed Fargo Diversion Channel has been constructed.

Emergency Spillway Capacity

The project has several problems with the features available to release stored water from the reservoir. The recent National Dam Safety Study indicated that Orwell Reservoir should probably have additional emergency spillway capacity for rare and large flood events, such as the probable maximum flood. If the tainter gate is opened to its maximum design opening of 25 feet, the probable maximum flood would raise the pool level to within 1 foot of the top of the dam. The current Corps design criteria requires that 5 feet of freeboard be available. Thus, some additional spillway capacity is needed, according to current Corps design criteria. The reconnaissance report containing the St. Paul District and North Central Division comments is currently being reviewed by the Office of the Chief of Engineers (OCE) in Washington, D.C.

Recent developments in the Corps dam safety evaluation program require a risk analysis of proposed dam safety-related project features such as the contemplated emergency overflow spillway for Orwell Dam. When technical criteria indicate that a design modification is needed, then the additional risk analysis is called for. The risk analysis is intended to compare the cost of a project safety feature with the potential damage should the project fail because of the lack of the proposed feature. The risk analysis is currently being reviewed by OCE.

Low-Flow Controls

The two existing 24-inch low-flow conduits and the single large tainter gate have low-flow operation problems. The two existing low-flow valves can only operate fully open or fully closed. The present double disc type valve vibrates and cause excessive wear when left partly open. The tainter gate is used to control low-flow releases for those conditions when partially open valves would normally be used. However, because of its large size, the tainter gate is not an adequate substitute for the low-flow valves. Vibration and erosion of the tainter gate lip can occur occasionally during very small gate openings. Setting the tainter

gate for low-flow conditions is a trial-and-error process during a hydrologic condition that requires a fairly precise operation. An alternative style valve, such as a butterfly or knife valve, could be installed to allow the low-flow conduits to operate over their entire range. Replacement of the 24-inch double disc valves will require excavation of substantial amounts of surrounding concrete. Replacement of these valves is recommended. Further information is in the Evaluation section of this report.

Stilling Basin

A preliminary hydraulic analysis done in 1979 indicated a potential for scour downstream of the stilling basin under certain tailwater conditions. Although no modifications are scheduled at this time, the stilling basin design may be reviewed at a future date. The stilling basin design was not reviewed as part of this ROPE study.

A second problem is that some periodic inspections of the stilling basin require dewatering of the basin. A recent inspection was accomplished by Corps divers. However, diver inspections do not provide all the necesary condition information. The two existing low-flow conduits and the tainter gate discharge into the stilling basin. Thus, they cannot be used during dewatering inspections of the stilling basin. The MDNR has indicated that a new project feature is needed to provide a continuous discharge to the river downstream of the dam during the inspections. The proposed low-flow replacement valves includes a system to provide such flows. This system is described in the Description of the Recommended Operation Plan section of this report.

Lack of Vegetation on Shoreline

Past operation of Orwell Reservoir has had an adverse effect on both aquatic and terrestrial vegetation at the project. Pool fluctuations of up to 22 feet regularly desiccate soils and allow them to freeze in the drawdown zone. Shoreline erosion during pool fluctuations results in

removal of fine particles from the soils in the drawdown zone, leaving a coarser, stepped reservoir bottom. Because of the fluctuating water levels and bottom substrate conditions, submersed and emergent vegetation cannot develop. This lack of vegetation in the littoral zone of the reservoir severely limits habitat quality for fish and other aquatic life. Only desiccation-tolerant aquatic plants and ruderal plants such as smartweed and burdock can survive on the exposed drawdown zone soils. Terrestrial vegetation above the drawdown zone has been destroyed in some areas by shoreline erosion. If pool fluctuations were reduced and timed correctly, the littoral zone of the reservoir and presently eroding shoreline areas could become valuable habitat for fish and wildlife.

HISTORY OF MAINTENANCE AND OPERATIONS

CHRONOLOGY OF EXPENDITURES

The table on the following page lists contract expenditures, by fiscal year, for the more than 30 years of dam operation. Total operation and maintenance costs are also listed.

REHABILITATION ACTIVITIES

The following paragraphs briefly describe previous major rehabilitation activities.

1976 Seepage Repair

Artesian pressures first became a cause for concern during the 1970 periodic inspection. At that time, a general wet condition was noted along the downstream toe. Clearing was recommended, along with construction of a drainage ditch and the installation of piezometers. This work, performed in 1973, was only partially effective. In 1976, a 15-inch perforated PVC toe drain was installed, and a 150-foot-wide

Summary of Contracts and O&M Costs

Fiscal Year	Contract Work	Contract Amount	O&M Cost
1951	Construction of Orwell Dam	$1,183,941*	$ -
1952	Reservoir clearing	36,198*	-
	Dam tenders bldg. and service bldgs.	31,694*	
1953	Utility line relocations	3,703*	8,648
	SAR #2 road	30,141*	
	Emergency bulkheads	57,400*	
1954	Reservoir fencing	1,724*	17,549
1955	Recorder house	400	10,322
1956	-	-	16,171
1957	Tainter gate housing	18,900	35,977
1958	-	-	21,102
1959	-	-	13,882
1960	-	-	13,951
1961	-	-	15,720
1962	-	-	15,377
1963	-	-	17,806
1964	-	-	25,562
1965	-	-	31,917
1966	Rubber seals	3,300	20,024
1967	-	-	27,933
1968	-	-	27,594
1969	-	-	39,392
1970	-	-	30,798
1971	-	-	48,542
1972	Plans and specs. for road	4,639	42,232
	Recreation facilities	13,407	
1973	Plans and specs. for road	8,278	70,043
	Ditch excavation	9,390	
1974	New road below dam	58,405	110,817
1975	-	-	76,006
1976	Seepage repair	19,958	260,184
	Sanitary facilities	27,182	
1977	Repair earth dam	67,854	181,576
1978	Water quality	5,400	172,493
	Test well	22,240	
1979	Maintenance building	69,000	260,164
	Relief wells	105,286	
1980	Maintenance building	59,125	222,273
	Dam maintenance	38,547	
1981	Hydrologic analysis	15,500	164,830
	Cultural resources	14,580	
1982	Hydrologic analysis	16,309	159,738
	Cultural resources	2,981	
1984	Sandblast and paint tainter gate		50,000

* Not included in O&M cost.

berm, up to about 5 feet deep, was then constructed along the entire dam toe adjacent to the existing road. The berm was extended to 250 feet over the old river channel area along the right abutment.

1977 Earth Dam Repair

In May 1977, boils of significant size with some displacement of material (sand cones) were detected in the bottom of the spillway discharge channel. To relieve the pressure and provide adequate safety, relief wells were installed along the right channel bank in 1979.

PUBLIC INVOLVEMENT FOR ROPE

During the problem definition period of the study, the goals of the public involvement effort were to (1) inform the affected public of the study, (2) actively seek public input into defining problems, needs, and opportunities relating to operation of Orwell Reservoir, and (3) develop a complete list of interested parties, both governmental and private, for coordination of the study activities. To accomplish these goals, a study initiation notice was mailed to about 165 offices and interested individuals. In addition to written and oral comments received in response to the notice, key agencies were contacted by telephone to request their active participation, and two briefings were held in the Twin Cities area. Copies of a number of correspondence items are in an appendix to this report.

During plan formulation and evaluation activities, a number of meetings and telephone conversations were held with representatives of the Minnesota Department of Natural Resources (MDNR) and U.S. Fish and Wildlife Service. In addition, MDNR and U.S. Fish and Wildlife Service personnel participated in a field inspection of project lands and boat tour of the reservoir. The proposed test of a new operation plan for Orwell Reservoir contains a significant amount of information and recommendations from the MDNR.

A final public notice, dated January 7, 1986, was mailed to the entire mailing list with a summary of study conclusions and the District Engineer's recommendations.

PROBLEMS, NEEDS, AND OPPORTUNITIES

The following problem definition sections present information that was gathered and assumptions that were made during this scoping process concerning the significant resources involved with the Orwell Reservoir and its operation. The information was obtained from the various public agencies or groups or from in-house experts concerned with the particular resource. Accurate problem definition provided a necessary basis for formulation of alternative operation plans and the proposal of a selected test plan for Orwell Reservoir. The result of the problem definition and public involvement effort is a list of planning constraints and objectives, as listed in this section of the report. The constraints and objectives guided plan formulation and evaluation.

The following problem definition sections and the later planning objective statements address the identified problems on a problem-by-problem basis. However, many of the problems are interrelated and must be considered together or as a trade-off when proposing a solution.

WATER SUPPLY

Short-Term Municipal and Industrial Problems

Water department representatives from the two cities of Fargo, North Dakota, and Moorhead, Minnesota, indicated concern about the quality of the water in the Red River. The Red River is a water supply source for both cities. During a telephone conversation, the Water Department representative from Moorhead indicated that in December 1984 and January 1985 large releases from Lake Traverse had caused that city to expend $80,000 over budget for water treatment chemicals. He suggested that the higher quality water from Orwell Reservoir be used to dilute

releases from Lake Traverse on the Bois de Sioux River. Lake Traverse is also a Corps-operated reservoir.

Another suggestion from the Moorhead official is that smaller, more gradual Lake Traverse releases should be made over a long period of time, rather than large, quicker releases over a short period. Moorhead takes its water from the Red River whenever it is available at sufficiently high quantity and quality. Otherwise, Moorhead pumps ground water that is more expensive to pump and usually more expensive to treat. Most of the communities along the Red River use similar water supply systems.

Moorhead has not experienced winter flows that were too low, and it would prefer the summer flows supplemented to flush algal blooms. Moorhead does little ground-water pumping in the winter; instead, the city does most of its ground-water pumping in the summer to satisfy peak demand.

Fargo indicated that its past operation has worked well in supplying water to the community. That city would not like to see Orwell Reservoir operation changed materially for water supply purposes. However, summer operation should be reviewed to provide increased flows that would improve aesthetic appearance along the river during low-flow conditions. Fargo's National Pollution Discharge Elimination System (NPDES) permit sets limits on biochemical oxygen demand (BOD), suspended solids, pH, and coliform bacteria in the effluent from the waste-water treatment plant. The BOD limit depends on the flow in the river. Fargo also has an intake and pipeline to the Sheyenne River, but the city prefers the quality of the Red River water.

Fargo is also concerned that the volume available in the Red River is used as a decision criteria by the North Dakota Health Department to limit the quantity of effluent from the their waste-water treatment plant. The city is not allowed to discharge effluent under the ice, so often it must store effluent until summer months. However, during the

summer, lower flows can limit the amount of effluent allowed to be released.

The cities of Wahpeton, North Dakota, and Breckenridge, Minnesota, indicated that they no longer depend on river water for their main supply. Both cities have switched over to ground-water systems for their primary source of municipal and industrial water. Breckenridge maintains its intake in the Ottertail River for an emergency source of supply.

Water Supply Sources

City	Red River	Sheyenne River	Ground Water
Breckenridge			X
Fargo	X	X	X
Moorhead	X		X
Wahpeton			X

Sustained Drought (Municipal and Industrial)

The preceding table indicates that all four cities have systems in place to obtain ground water. The 1976 drought required the installation of some of the present ground-water equipment. In dry periods, such as the 1976 drought, the ground-water systems should prove to be more dependable than the available surface-water supplies, including Orwell Reservoir. In fact, in 1976, the evaporation losses were so great that emergency water supply releases from Orwell Reservoir never made it to the consumers. Thus, the Orwell Reservoir can provide little relief during a sustained drought. The four cities most affected by the Orwell project, listed on the table above, would have to depend on their ground-water systems during a sustained drought.

Long-Term Municipal and Industrial Problems

The recent Fargo-Moorhead urban study considered the long-term water supply and demand needs for municipal and industrial uses. During that

study, information was gathered from a number of agencies concerned with water supply in the Red River basin. One problem, made quickly evident, was that little comprehensive effort was being made to coordinate sources with projected needs on a long-term and basin-wide basis. Also, there is an overall tendency by the individual water users to consider their water demand and supply for no more than several years in the future.

The public contacts made for the problem appraisal report appeared to support that tendency. Thus, the existing information is insufficient to determine, within the scope of this study, how the operation of Orwell Reservoir would contribute to the long-term water needs of the Red River basin.

Long-term and comprehensive water supply planning is probably needed for the Red River basin. Such planning should include water quality constraints and water conservation concepts. A HEC-3 computer model developed by the Corps during the Grand Forks-East Grand Forks urban study could be expanded and updated to be used as a tool for such comprehensive water supply planning. An agency, such as a coalition of the involved States, or possibly the Corps of Engineers, should take the lead to provide the basin-wide perspective required to accomplish comprehensive planning. However, support and requests for the work would be needed from both States involved in the basin. Also, recent Corps policy indicates that single-purpose water supply projects are not in the Federal interest. That policy would need to be reviewed for its application in such a study.

Irrigation

Long-term water supply for irrigation is complex and can have basin-wide consequences. Irrigation is interrelated with municipal and industrial water supplies. Thus, any basin-wide water supply planning effort should also consider present and projected irrigation demand. Without such a comprehensive water supply plan, it is impossible to determine

the complete and long-term effect that Orwell Reservoir might have on irrigation requirements.

An assumption was made for considering the more short-term effects that the operation of Orwell might have on irrigation. The assumption is that any ground-water-based irrigation would have imperceivable effects or demands on Orwell Reservoir and its operation. However, if any irrigators have intakes in the Ottertail River downstream of the reservoir, or in the Red River upstream of Fargo-Moorhead, then their demand for water should be considered. There are no withdrawals for irrigation directly from the reservoir at the current time. Future withdrawals are unlikely because of the elevation difference between the reservoir and nearby cropland. In Minnesota, information concerning irrigation withdrawals from the rivers is available from the Minnesota Department of Natural Resources water permit program. Each irrigator is required to obtain a permit. Irrigation withdrawals from the Ottertail River is a supporting purpose for supplementing flows for instream needs during the summer.

URBAN FLOOD DAMAGE REDUCTION

Wahpeton, North Dakota, and Breckenridge, Minnesota, are located where the Ottertail and Bois de Sioux Rivers join to form the Red River of the North. In the past, both communities have suffered flood damages and collectively have expended significant resources in fighting floods. The last flood fight of significant proportion occurred in April 1979. The 1979 flood approximated the 23-year flood at Breckenridge and Wahpeton. Orwell Reservoir prevented about $670,000 of flood damage in 1979 (agricultural and urban) and a cumulative amount through 1979 of about $3,461,000. However, both communities can expect to continue to be exposed to damage from the larger magnitude floods. Any consideration of modifications to the Orwell Reservoir operation plan must include an evaluation of effects on the flood damages at Wahpeton and Breckenridge.

These two communities are the only urban areas that receive measurable flood control benefits from operation of the Orwell Reservoir. The other communities in the study area are either too far from the Ottertail River or too far downstream on the Red River to receive any perceivable amount of flood control protection from Orwell Reservoir.

Flood profile information for this evaluation of Orwell Reservoir was taken from the 1978 Wilkin County Flood Insurance Study (FIS). While these profiles may be subject to update in the future, they are satisfactory for this level of economic review and comparison of alternative operation plans for Orwell Reservoir. These profiles represent the flooding that occurs in March and April. This flooding is caused by runoff from the drainage areas below Orwell and Traverse Dams. The flood peak from the larger drainage area upstream of Orwell Reservoir usually comes in May or June. The second flood peak is delayed and attenuated at Breckenridge to about half the discharge of the April floods because of the natural storage provided by all the lakes and wetlands in the basin upstream of Orwell Dam. Operation of Orwell Reservoir provides flood control benefit during both the April and June flood events.

A flood insurance report, for Wahpeton, North Dakota, is currently under review and should provide additional floodplain management information to the city decision-makers when it is released. Because of its proximity to Wahpeton, Breckenridge should also receive some floodplain management information from the report. The flood profiles developed for the Wahpeton FIS tend to follow the 1978 Wilkin County FIS profiles very closely in the reaches considered in this study.

As part of this study, an inventory of properties located in the 100-year floodplain was assembled for Wahpeton and Breckenridge. The 500-year floodplain was not used for this inventory because the most significant effects of the Orwell Reservoir operation occur within the 100-year floodplain. This information was combined with the flood profile information to estimate the amount of flood control benefits

provided by the existing Orwell Reservoir operation. Flood control benefits were also estimated for alternative operation plans considered during this evaluation.

In a January 1985 letter, the city of Wahpeton expressed concern about the effect that Orwell Reservoir operation may have during flood times for the city. Wahpeton's flood-prone areas are nearly all public property. The public areas that are most flood-prone are parks. During past floods, the city has constructed an emergency levee system for those areas. In 1979, the city sustained about $27,000 in damages, and its flood fight prevented about $530,000 in additional damages. However, the larger floods will continue to require the expenditure of resources in flood fighting. The Corps of Engineers has tentatively scheduled a condition survey of Wahpeton's emergency levees for 1988 as part of an inventory and condition survey of emergency levees for the entire St. Paul District.

In a joint resolution dated February 19, 1985, the cities of Breckenridge and Wahpeton requested that the Corps evaluate the feasibility of dredging the Red River and modifying Kidder Dam to reduce the potential for flood damages. Dredging of the Red River would not be feasible for reducing flood damages for the two cities. The District provided some technical support information for operation of the flashboards on Kidder Dam. Additionally, the economic information developed in this ROPE study may indicate feasibility for some other flood damage reduction features at Wahpeton and Breckenridge. The District will provide a final response to the joint resolution by letter when the results of this ROPE study have been reviewed.

Breckenridge has a fairly extensive floodplain that includes several hundred homes and up to 50 businesses. During the 1979 flood emergency at Breckenridge, the Federal Government provided 25,000 sandbags, 25 rolls of polyethylene sheeting, and 7 pumps at a cost of about $8,000. The Federal Government also aided in construction of the emergency levee by providing a contractor to construct 150 feet of new levee at a cost

of about $2,200. Breckenridge sustained about $40,000 in damages, and its flood fight prevented about $400,000 in damages.

AGRICULTURE FLOOD DAMAGE REDUCTION

Agricultural flood damages occur downstream from Orwell Dam in the Ottertail River floodplain in an area of about 38,000 acres. The damages are caused by the May or June flooding events (secondary peaks) and not the earlier April peak events because of the crop planting times. The flood-prone area is generally located between river miles 9.7 and 24.8, and mainly south of the Ottertail River. The St. Paul District has obtained 1980 land-use data for that flood-prone agricultural area from the Minnesota Land Management Information Center (LMIC). The land-use information is stored by LMIC in a computer data base set up into 3-1/2-acre grid cells that show the crop types or other land uses in each grid cell. The information is displayed in graphic form on photographs that have been included in the evaluation section of this report.

Flood discharges for the agricultural damage reach were developed by lag routing flood hydrographs from the Orwell Dam. The flood discharges were converted to area flooded by using a curve found on Plate 12 of the current reservoir regulation manual. (The curve is shown on Figure 4.) Thus, average annual flood damages for the without-project condition can be estimated for flooding from the Ottertail River by assuming that the Orwell Dam does not exist. Also, the average annual flood control agricultural benefits from the existing Orwell Reservoir project and alternative operation plans can be similarly computed by lag routing floods through the alternative reservoir operation plans.

The existing Ottertail River channelization project, built by the Corps in 1954, was in good condition when it was last inspected. The channelization project leads through and downstream from the agricultural damage area. The channelization project works together with Orwell Reservoir operation to reduce agricultural flood damages

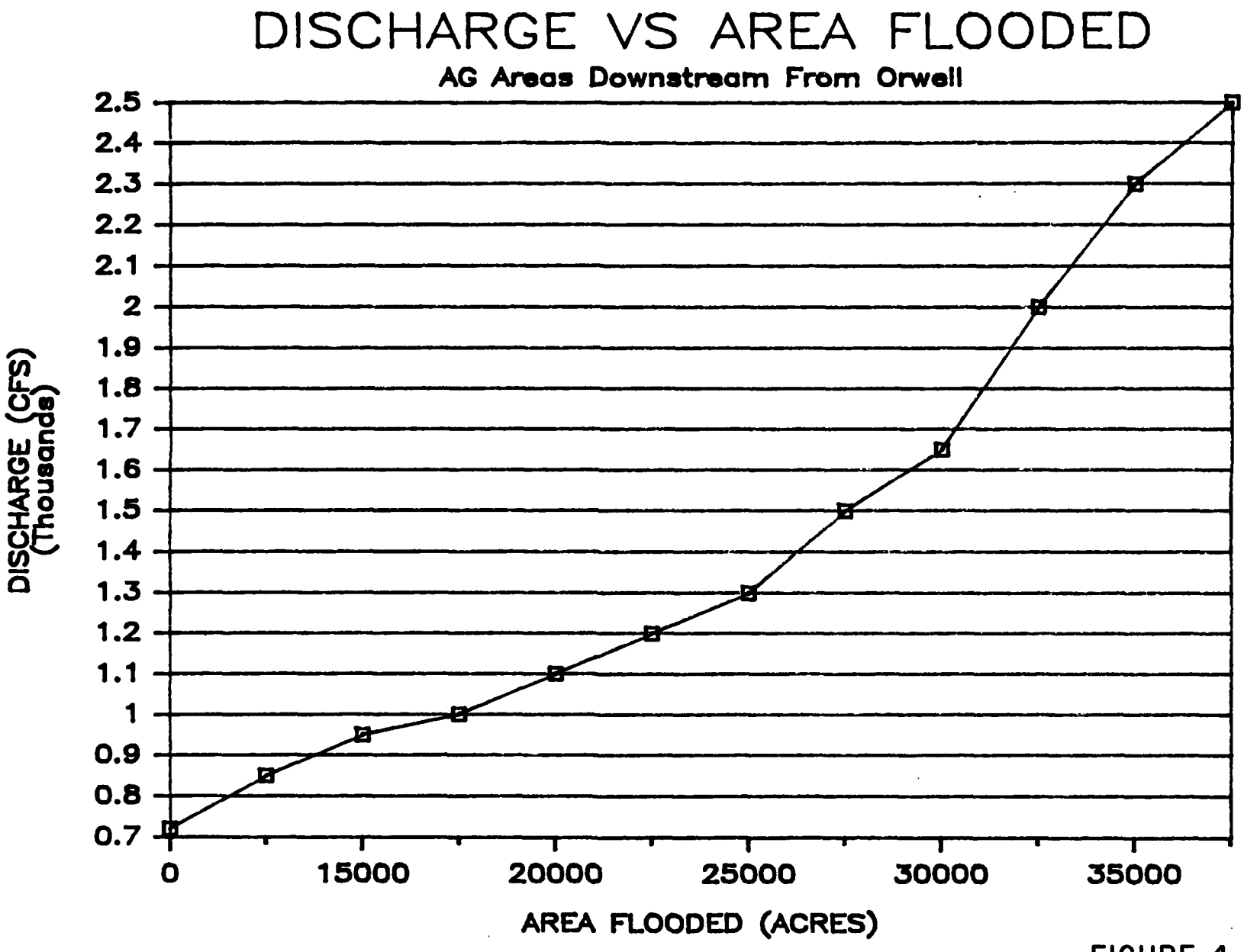

DISCHARGE VS AREA FLOODED
AG Areas Downstream From Orwell
DISCHARGE (CFS) (Thousands)
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0
15000
20000
25000
30000
35000
AREA FLOODED (ACRES)

FIGURE 4

from the smaller floods. However, the agricultural flood damage areas continue to be damaged by the medium and larger floods. Any consideration of modifications to the existing Orwell Reservoir operation plan must include an evaluation of effects on the affected agricultural damage area.

OTTERTAIL RIVER SUMMER LOW FLOWS AND INSTREAM FLOW NEEDS

Pollution abatement (waste assimilation) is an authorized purpose of the Orwell project. Presently, the reservoir is filled from mid-June to early September. The stored water is released for pollution abatement or dilution purposes beginning in late fall and throughout the winter, based on conditions in the 1940's. At the time the project was formulated in the late 1940's, a substantial amount of untreated effluent was being released into the Red River.

During the fall and winter, large amounts of untreated effluent were released from sugar beet processing plants and other sources. The natural fall and winter flows were supplemented with discharges from the Orwell Reservoir to aid assimilation of the waste-water effluent from sugar beet processing and other sources. Since the 1940's, water quality laws have been passed that require these effluents to be treated to higher quality standards. Thus, the large pollution abatement or waste assimilation releases are no longer required during the fall and winter.

During the recent public involvement activities, summer low-flow releases were identified as a concern by Fargo and Moorhead. Wahpeton and Breckenridge also mentioned concern about summer low-flow periods and the related aesthetic problems, although the cities no longer rely entirely on the river for water supply. All four cities mentioned that, during summer low-flow periods, Ottertail and Red River flows should be supplemented from Orwell Reservoir or from the overall Ottertail basin for the following reasons:

1. To help flush algal blooms in the Red River.

2. To dilute releases from Lake Traverse when those releases are of the poorest quality.

3. To allow for larger releases of waste-water treatment plant effluent (to ease the biochemical oxygen demand constraints in effluent releases).

4. To improve aesthetic appeal of areas near the Red River.

Water quality was also indirectly identified as a concern or as a constraint for many of the other purposes being considered. For example, water quality is important for water-contact activities such as swimming and canoeing. Water quality is also an important characteristic of fish and wildlife habitat in the Ottertail River.

OTTERTAIL RIVER INSTREAM FLOW REQUIREMENTS

The Minnesota Department of Natural Resources (MDNR) identified specific instream flow needs that are water use demands separate from summer low-flow, water quality, and water supply needs identified by others. Fortunately, the releases for all of these purposes are usually most critical for the same low-flow season of roughly July 15 to September 20, plus or minus a few weeks.

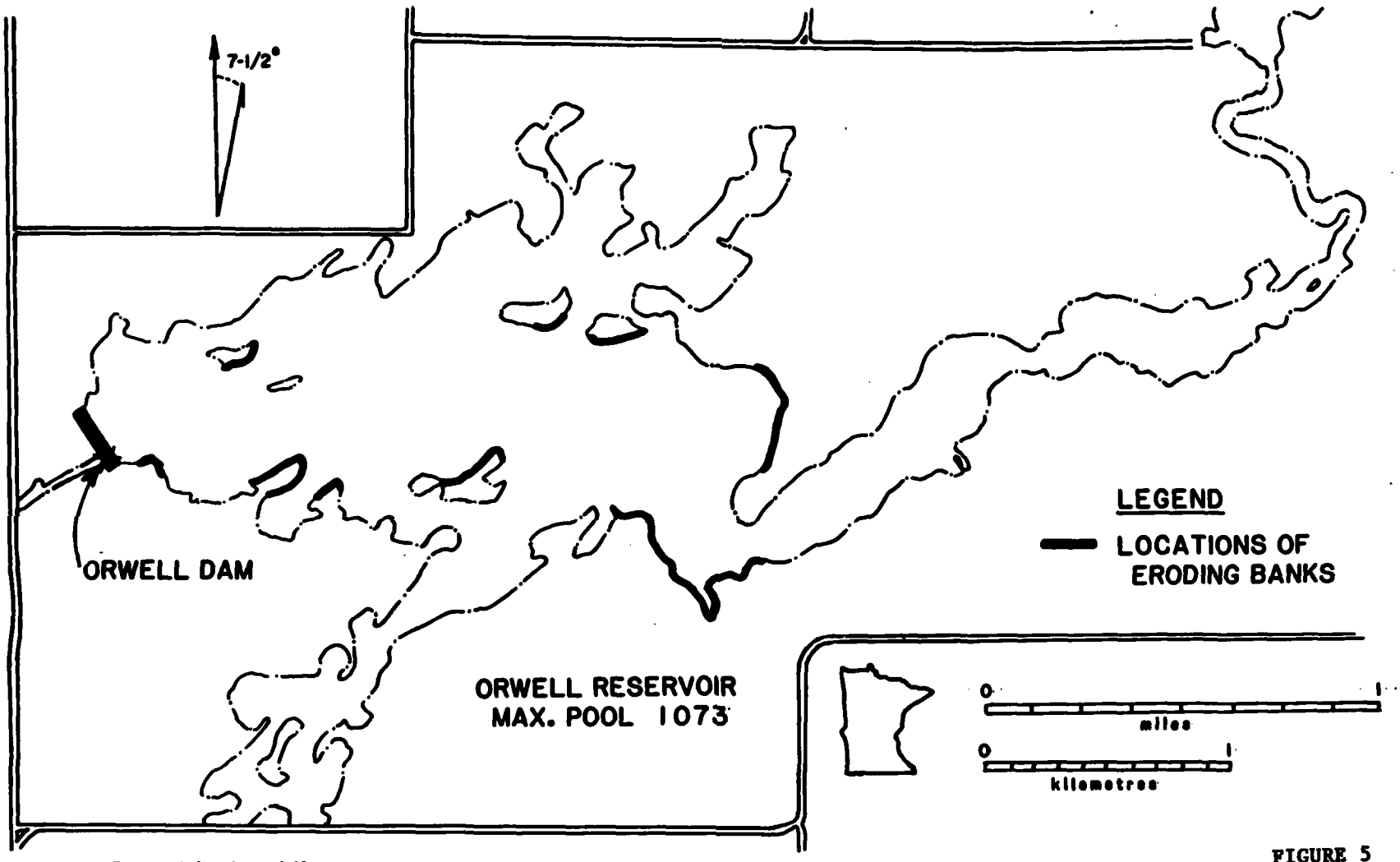
Aquatic life and recreation opportunities are greatly affected by stream discharge. The tailwater of the Orwell Dam supports an important sport fishery. In fact, the MDNR has indicated that the tailwater fishery is more important to their regional fishery planning than the fishery in the reservoir. The aquatic habitat of the entire Ottertail River below Orwell Dam is important and has been documented in a recent inventory report by the MDNR (Hanson et al. 1984).

The MDNR has recently been working on a proposal to develop the Ottertail River for recreational boating (see page 42). If such a proposal is successfully implemented, it could have a positive effect on the regional economy. Reservoir releases during the recreational boating season have an effect on the value of the river below Orwell Dam for recreational boating.

The MDNR has provided target discharges for aquatic life and recreational boating as well as minimum flow requirements for the protection of aquatic life. The line graph on page 114 summarizes the MDNR recommendations. In addition, the MDNR has provided recommendations for ramping of flow changes to prevent damage to the stream community. The table on page 59 summarizes the MDNR ramping recommendations. These targets have been incorporated into the plan formulation to the greatest extent possible. Another concern from the MDNR is that some larger flows should be allowed to pass so that the channel shape does not change because of sedimentation. The larger flood peaks will continue to pass through the Orwell project relatively unaffected, so that the existing channel should not become silted in.

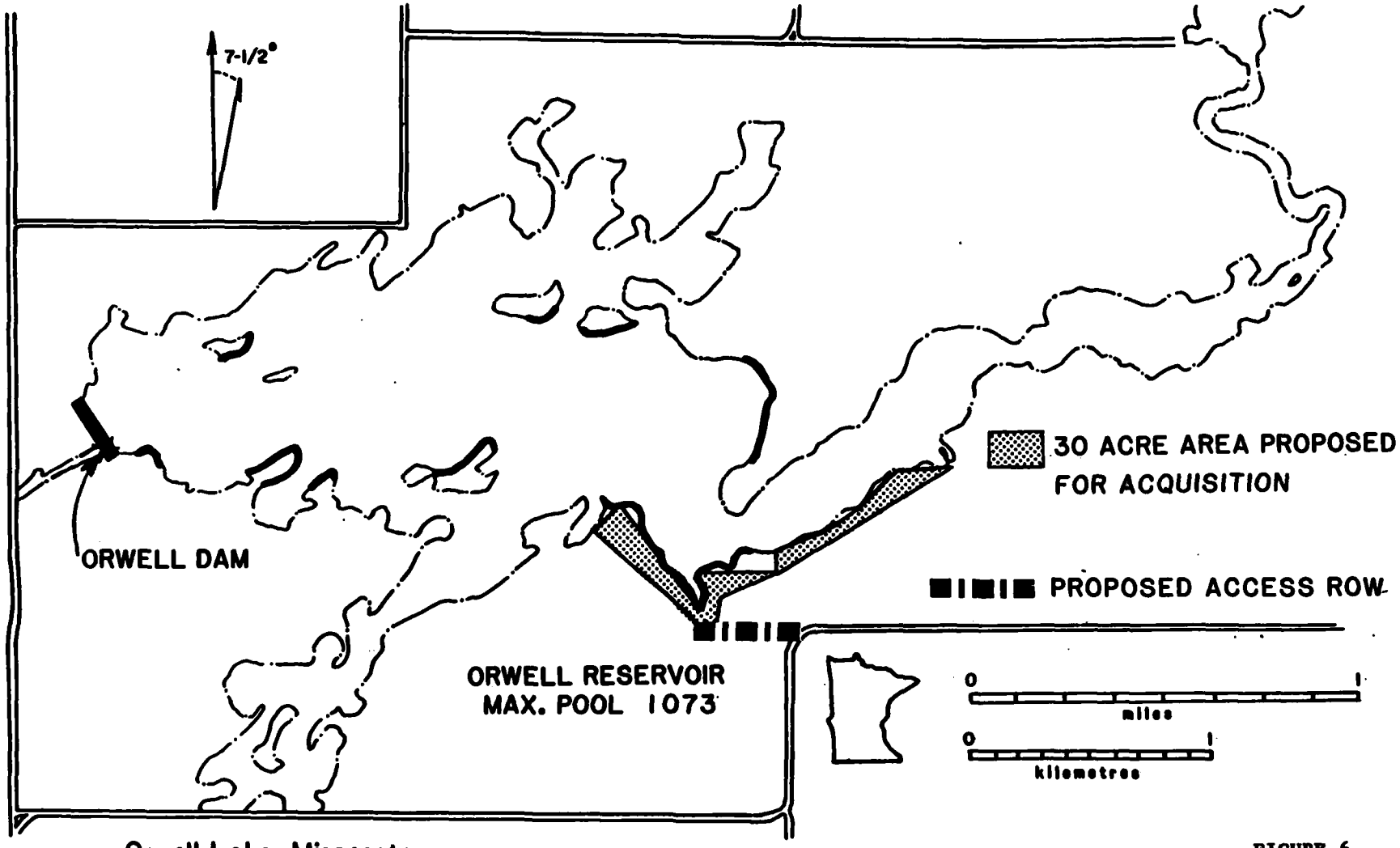
SHORELINE EROSION

A considerable amount of shore erosion has occurred since Orwell Reservoir was first impounded. Steep banks have developed on about 35 percent of the high water shoreline of the main lake; many of the banks are nearly vertical. Figure 5 shows the locations of the actively eroding banks. Erosion has progressed onto private lands in one area, and the St. Paul District has proposed a land purchase to correct that problem. Figure 6 shows the area being proposed for acquisition. A real estate design memorandum is presently under review by Corps higher authority at the North Central Division (NCD) in Chicago, Illinois, and the Office of the Chief of Engineers (OCE) in Washington, D.C. NCD and OCE approval of a real estate design memorandum is necessary.



Orwell Lake, Minnesota
326 metre (1070-foot) level

FIGURE 5
FLOOD CONTROL PROJECT
OTTER TAIL MINN.
ORWELL RESERVOIR
LOCATIONS OF ERODING BANKS



Orwell Lake, Minnesota
326 metre (1070-foot) level

FIGURE 6
FLOOD CONTROL PROJECT
OTTER TAIL MINN.

ORWELL RESERVOIR

LOCATIONS OF ERODING BANKS

A report entitled Shoreline Erosion Process, Orwell Lake, Minnesota, by John R. Reid, University of North Dakota, was prepared in January 1983. That 2-1/2-year study was conducted to determine the causes of bank erosion in the lake and ways to slow its rate and magnitude. The report identified wave action accompanying high pool levels and, to a lesser extent, freeze-thaw and rainfall as the primary processes of erosion. The report recommended lowering the normal full pool from 1070 to 1068 msl and planting vegetation on the slopes, which would require some shaping of the slopes. The report also recommended that the pool elevation be kept under 1068 as much as possible.

The shoreline erosion process is evidently not introducing significant amounts of sediment. Part of the typical monitoring program accomplished for Corps reservoirs includes siltation ranges taken on a regular basis. There were 24 siltation ranges established in 1955, and repeat soundings have been taken at the same ranges in January 1964 and in January 1985. Preliminary results from the 1985 field work indicate that most of the change has been occurring at the shoreline. Material appears to be eroding away from the shoreline areas, but where that material is being deposited is not readily apparent from the survey bottom profiles. A few of the ranges indicate that up to a foot of material has been deposited in scattered bottom areas. However, the storage capacity of the reservoir has not been significantly reduced.

WILDLIFE RESOURCES

The Ottertail River valley in the vicinity of Orwell Reservoir provides a variety of high-quality wildlife habitats in a region that is intensively farmed. The project is near the intersection of three major vegetation zones: coniferous forest, hardwood forest, and prairie. The diversity of wildlife at the project is due in part to the variety of vegetation types in the area and the presence of grasslands, forest, shrub, wetland, and open-water areas at the reservoir. The Minnesota Department of Natural Resources (MDNR) leases 1,957 acres of project land from the Corps of Engineers for wildlife management purposes. The

following table provides acreages by vegetation cover type on the Orwell Wildlife Management Area (OWMA).

Cover Types at the Orwell Wildlife Management Area
(From MDNR Wildlife Management Area Inventory)

Cover Type	Acres
Ash woods	2
Planted wildlife cover - shelterbelts	45
Wildlife food plots - cropland	35
Emergent wetland vegetation	350
Grassland	702
Low deciduous cover	80
Low shrub	22
Mud flat	1
Natural prairie	22
Oak woods	28
Other deciduous woods	632
Open water	56
Sand and gravel(1)	957

(1) Reservoir drawdown zone

The MDNR observed 83 species of birds and 14 species of mammals in the Ottertail River valley during a recent survey (Hanson et al., 1984). Many additional species are known to be present (Hennings, Parker, and Hanson, 1980). Orwell Reservoir and the connected and adjacent wetland areas provide waterfowl habitat. Mallards, shovelers, and blue-wing teal use the wetlands at the Orwell project for nesting, particularly the south arm of the reservoir (Falk et al., 1975). Numerous waterfowl species use the reservoir during migration. The MDNR has designated about one-quarter of the reservoir as wildlife sanctuary (see Figure 1), primarily to protect migrating waterfowl. Non-game bird species of interest that may occur at the reservoir include the bald eagle, osprey, white pelican, sandhill crane, and common loon.

The upland areas of the OWMA are managed by the MDNR primarily for pheasants and white-tail deer. The MDNR has seeded grassland areas, has planted 45 acres of shelterbelts, and annually plants 20 to 30 acres of food plots.

White-tail deer is the only big-game animal in the project area. Ring-necked pheasants, ruffed grouse, and cottontail rabbit are the important small game species. Muskrat, beaver, mink, raccoon, skunk, river otter, red fox, and coyote are the furbearers that occur near Orwell Reservoir.

The MDNR has identified in meetings and by letter (see the correspondence appendix, pages A-5 to A-7) fish and wildlife habitat deficiencies at the project that are caused by reservoir operation. The following paragraphs describe how present reservoir operation limits wildlife habitat values.

Terrestrial wildlife has not been greatly affected by reservoir operation, because of the active food and cover management by the MDNR on the wildlife management area. Pool fluctuations, however, prevent the full development of riparian vegetation along the reservoir shorelines, such as reed canary grass, willows, and cattails, which provide valuable cover for pheasants. Also, shoreline erosion has resulted in direct losses of trees and other terrestrial vegetation along about 35 percent of the reservoir shoreline.

Water-oriented wildlife are greatly affected by reservoir operation. At higher pool elevations, the reservoir inundates several connected wetland areas and over 300 acres of shallow embayment in the south arm of the reservoir (Figure 1). Some of these peripheral wetlands retain water in their basin as reservoir pool elevation drops, while others drain more completely. Rising water levels during the nesting season can flood waterfowl and upland gamebird nests. Fluctuating water levels prevent the development of much perennial emergent vegetation in the wetlands that are directly connected to the reservoir, particularly the south arm. The lack of submerged and emergent vegetation in wetland

areas connected to the reservoir severely limits the value of these areas to nesting waterfowl because of the limited cover and scarcity of aquatic macroinvertebrates necessary for breeding waterfowl.

Falling water levels strand waterfowl nests and broods away from the pool, subjecting them to more predation. Falling reservoir water levels in the fall and early winter freeze out beaver and muskrat that require stable water levels for access from their lodges to feeding areas under the ice. Changing winter releases from Orwell Dam similarly affects furbearers downstream in the Ottertail River.

Clearly, more stable water levels are needed at Orwell Reservoir to improve wildlife habitat. These more stable levels can be accomplished through a combination of operational and structural measures that will be discussed later in this report.

FISHERY RESOURCES

Orwell Reservoir

The fish assemblage in the reservoir is dominated by carp, buffalo, and bullheads. Some game and panfish species such as walleye, northern pike, and black crappie are present in low numbers.

Reservoir operation severely limits fish populations and the associated sport fishery. Pool fluctuations inhibit nest-spawning sunfish, crappies, and bass. High spring pool elevations can provide spawning habitat for northern pike in flooded vegetation, but rapidly falling water levels can strand fish eggs and larvae. High pool elevations in May and June provide spawning areas for carp in flooded vegetation and allow them access to peripheral wetlands around the reservoir, where they compete with waterfowl for submersed aquatic vegetation.

Pool fluctuations and erosion in the drawdown zone has prevented the development of a littoral zone in the reservoir, with submersed vegetation and macroinvertebrates necessary for the survival of larval and juvenile fish.

The reservoir fluctuations contribute to bank erosion, which in turn increases turbidity and siltation in the reservoir. Siltation covers hard substrates such as sand, gravel, and rock that provide spawning habitat for desirable sport fish. Turbidity reduces primary production and generally favors the success of rough fish over sport fish because of the morphological and behavorial adaptations of the rough fish.

Ottertail River above Orwell Reservoir and below Dayton Hollow Dam

The amount of "river" between Orwell Reservoir and the Dayton Hollow Dam ranges from 0.5 mile to 2.0 miles, depending on pool levels in Orwell Reservoir. The fish assemblage in this reach of the Ottertail River is dominated by carp, redhorse, and suckers. Walleye appear to be the most common game fish, with northern pike, largemouth bass, and crappie also present.

The largest impact of Orwell Reservoir operation on this portion of the Ottertail River is annual inundation of the river by the reservoir pool. At full pool (1070 feet msl), much of the river up to the Dayton Hollow Dam tailwaters becomes inundated. This inundation probably does not have a significant impact upon the existing fishery. However, it likely hinders to some extent the success of species more adapted to riverine conditions, such as the redhorse, suckers, and walleye.

Improvement of the fishery in Orwell Reservoir would probably improve the sport fishing opportunities in this reach of the Ottertail River. Species such as walleye would migrate out of the reservoir up to the Dayton Hollow tailwaters, enhancing the fishing opportunities there.

Stabilization of the reservoir pool would do the most to improve the reservoir fishery. Stabilizing the reservoir at a lower level would increase the length of river left in a flowing condition between the reservoir and the Dayton Hollow Dam.

Ottertail River below Orwell Dam

The Ottertail River downstream from Orwell Dam is a low-gradient river flowing 40 miles through level agricultural land. About 10.5 miles of the river have been channelized for agricultural flood protection. The reach immediately below Orwell Dam has the steepest gradient and best aquatic habitat. Redhorse, suckers, and carp are the dominant fish species in the river, and walleye are the most abundant gamefish. A popular sport fishery for walleye exists at the tailwaters of Orwell Dam.

Releases from Orwell Dam greatly affect aquatic habitat in the Orwell River. The existing operating plan calls for holding water over the summer for low-flow agumentation beginning in the fall (mid-September). In years of less than average precipitation, this plan can result in low flows in late summer that are less than optimal for the downstream fishery. Low instream flows can strand fish and benthic invertebrates and greatly reduce available fish habitat. Fluctuations in discharge rates can adversely affect fish spawning, fry and fingerling survival, and macroinvertebrate production, particularly rapid changes in discharge rate.

Recreational boating on the Ottertail River below the dam is affected by the volume and rates of change of reservoir releases. Excessively high or low flows can prevent boating on the river. Rapid increases or reductions in flow can produce problems for recreational boaters and anglers.

The opportunity exists to improve aquatic habitat and the sport fishery in Orwell Reservoir and the Ottertail River through changes in the reservoir operating plan. These measures are identified and their effects discussed later in this report.

CULTURAL RESOURCES

In 1981, a preliminary survey was undertaken to determine whether any significant cultural resource sites were present on project lands directly adjacent to the reservoir. The survey located two, and possibly three, prehistoric sites; and other sites are probably present. These areas are on top of the higher banks along the south and eastern shores. Unfortunately, these are the areas that are being eroded at the fastest rate by wave action.

Additional survey work was scheduled to be completed during fall 1985. The report from that survey is under review at the St. Paul District office.

The recommended actions that would contribute to the protection of any potentially significant cultural sites include reduction of shoreline erosion. A revegetation program for the actively eroding banks is described in the Implementation Activities section of this report. The normal full pool would be lowered from elevation 1070 to 1068 in an attempt to reduce shoreline erosion.

RECREATION RESOURCES

The Orwell Reservoir is in Otter Tail County in western Minnesota. The Minnesota State Comprehensive Outdoor Recreation Plan (SCORP), identifies thirteen economic development regions. Orwell Reservoir is in Region 4, which includes Otter Tail, Becker, Clay, Wilkin, Traverse, Grant, Douglas, Stevens, and Pope Counties. This region contains scenic, partially wooded (maple and basswood), moraine hills that parallel Interstate Highway 94 to the east. Farmlands and wetlands lie

west of I-94. Fergus Falls, approximately 9 miles northeast of Orwell, is just east of the major transportation corridor I-94.

Regional Recreation Features

The National Park Service has designated a scenic hiking trail called the North Country Trail, to be developed from New Hampshire to North Dakota. Figure 7 shows the proposed route along with other developed and proposed trails. In Minnesota, the North Country Trail has 18 miles completed from Longville to 6 miles south of Walker. The proposed trail would extend from Walker, Minnesota, through the Orwell area to Wahpeton, North Dakota. From Wahpeton, the trail would lead northwest along the Sheyenne River Valley to the Devils Lake basin.

Major Federal management units that offer outdoor recreational opportunities are shown in Figure 8. The Tamarac National Wildlife Refuge is in Becker County.

The following State parks are in Region 4: Maplewood in Otter Tail County, Glacial Lake in Pope County, Lake Carlos in Douglas County, and Buffalo River in Clay County. The Maplewood State Park, located approximately 17 miles northeast of Fergus Falls, offers camping, boat launching, picnicking, and trails for hiking, horseback, cross-country skiing, and snowmobiling. Inspiration Point, a wayside rest in Otter Tail County, provides a panoramic view from the second highest site in Minnesota. Figure 9 identifies the location of State parks, recreation areas, and wayside rests within a 75-mile radius of Orwell.

The State's major concentration of first- and second-priority wetlands for preservation (Figure 10) extends in a north-south band that covers most of Otter Tail, Becker, Douglas, and Pope Counties. These lake and wetland resources have produced a major vacation industry focusing on year-round fishing and autumn/winter waterfowl and deer hunting opportunities. A substantial pheasant population is supported in the southern portion of the region.

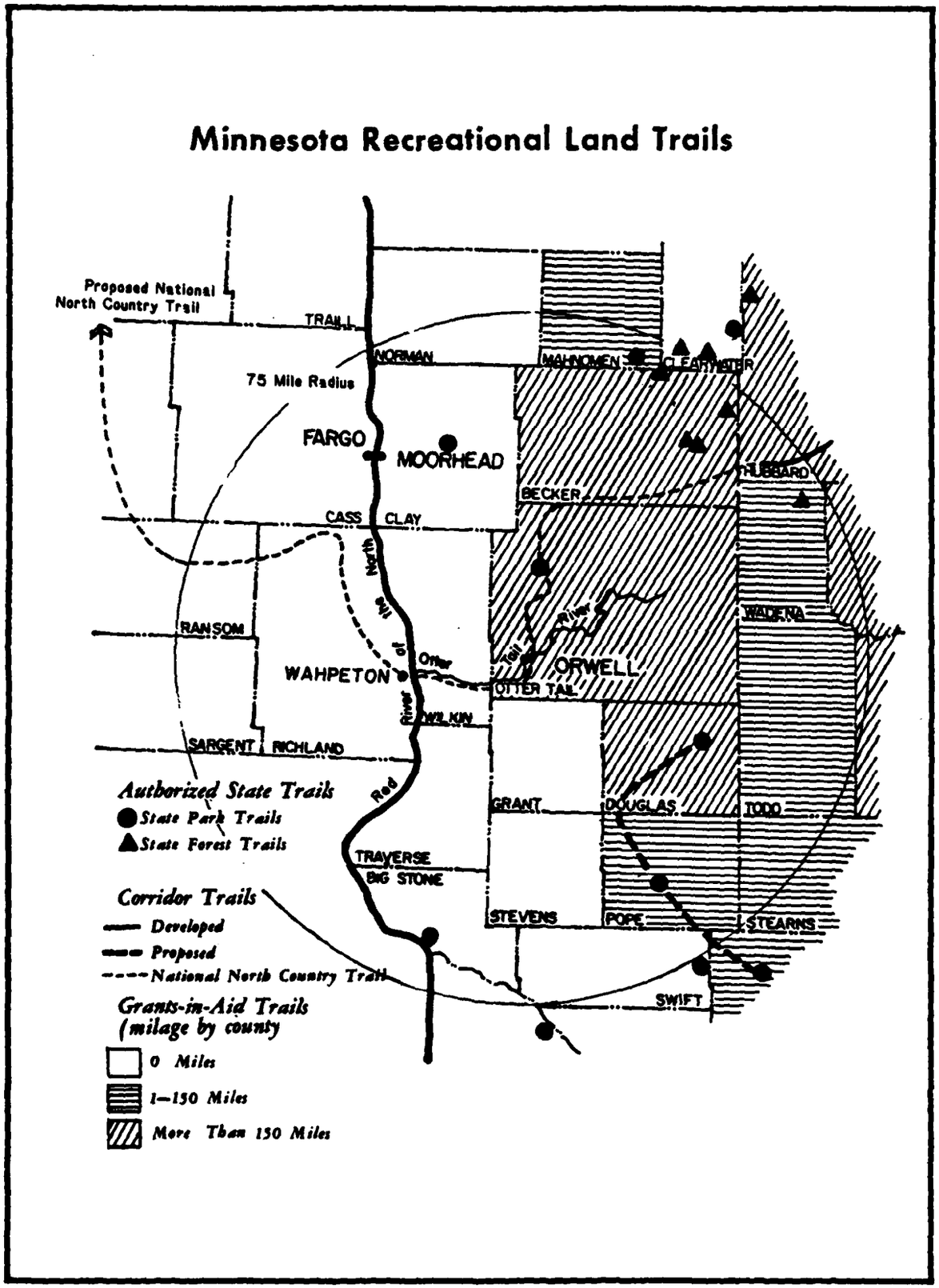

Minnesota Recreational Land Trails
Proposed National North Country Trail
TRAIL
NORMAN
MAHNOMEN
CLEARWATER
75 Mile Radius
FARGO
MOORHEAD
HUBBARD
BECKER
CASS
CLAY
North
Red
River
RANSOM
WADENA
WAHPETON
Otter
Tail
River
ORWELL
OTTER TAIL
WILKIN
SARGENT
RICHLAND
Authorized State Trails
State Park Trails
State Forest Trails
GRANT
DOUGLAS
TODD
TRAVERSE
BIG STONE
Corridor Trails
Developed
Proposed
National North Country Trail
STEVENS
POPE
STEARNS
SWIFT
Grants-in-Aid Trails
(milage by county
0 Miles
1—150 Miles
More Than 150 Miles

FIGURE 7

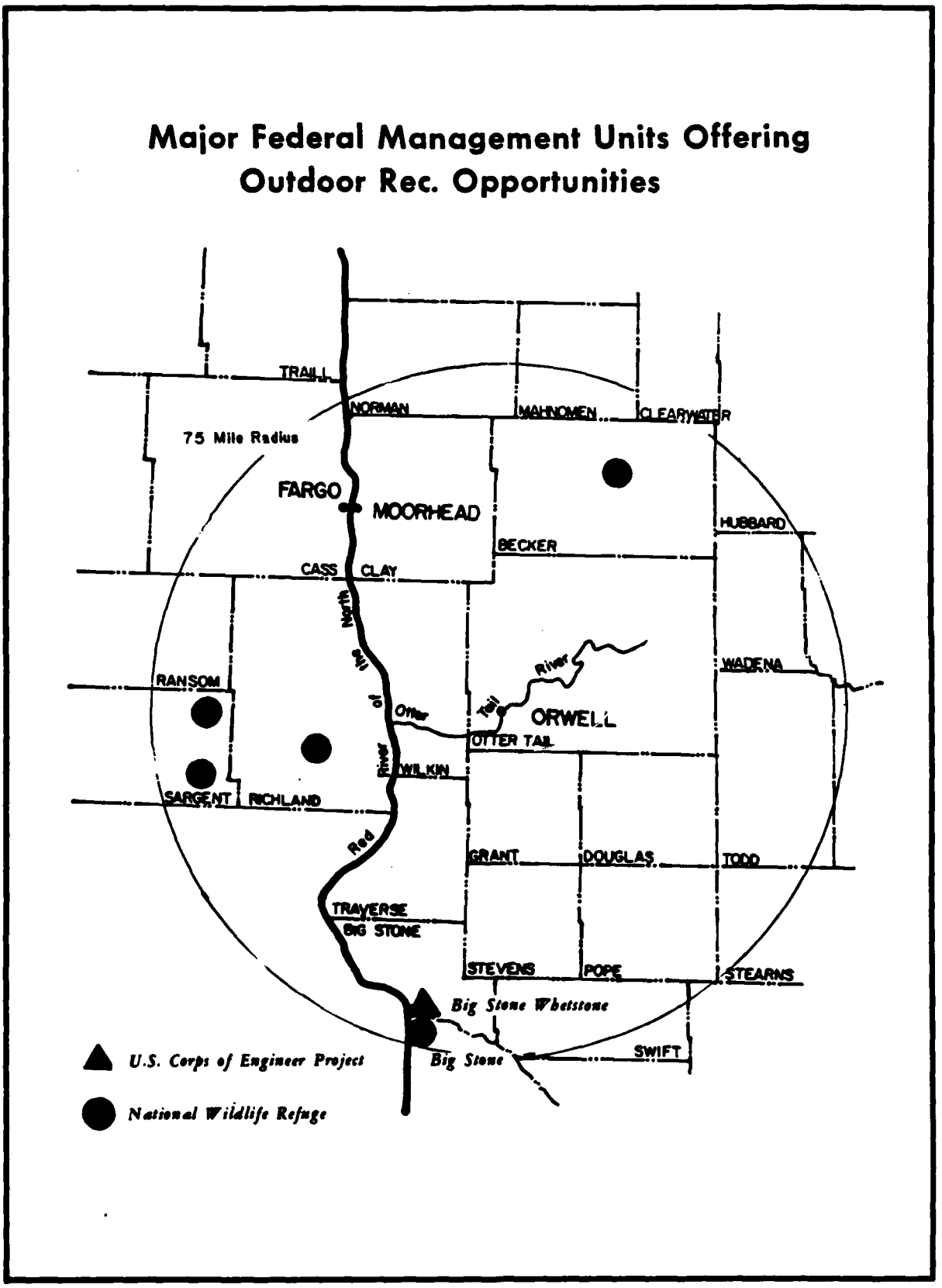

Major Federal Management Units Offering
Outdoor Rec. Opportunities
TRAILL
NORMAN
MAHNOMEN
CLEARWATER
75 Mile Radius
FARGO
MOORHEAD
HUBBARD
BECKER
CASS
CLAY
North
Red
River
RANSOM
Otter
Tail
River
ORWELL
WADENA
OTTER TAIL
WILKIN
SARGENT
RICHLAND
GRANT
DOUGLAS
TODD
TRAVERSE
BIG STONE
STEVENS
POPE
STEARNS
Big Stone Whetstone
SWIFT
Big Stone
U.S. Corps of Engineer Project
National Wildlife Refuge

FIGURE 8

Distribution of State Parks, Recreation Areas & Waysides Among Landscape Regions

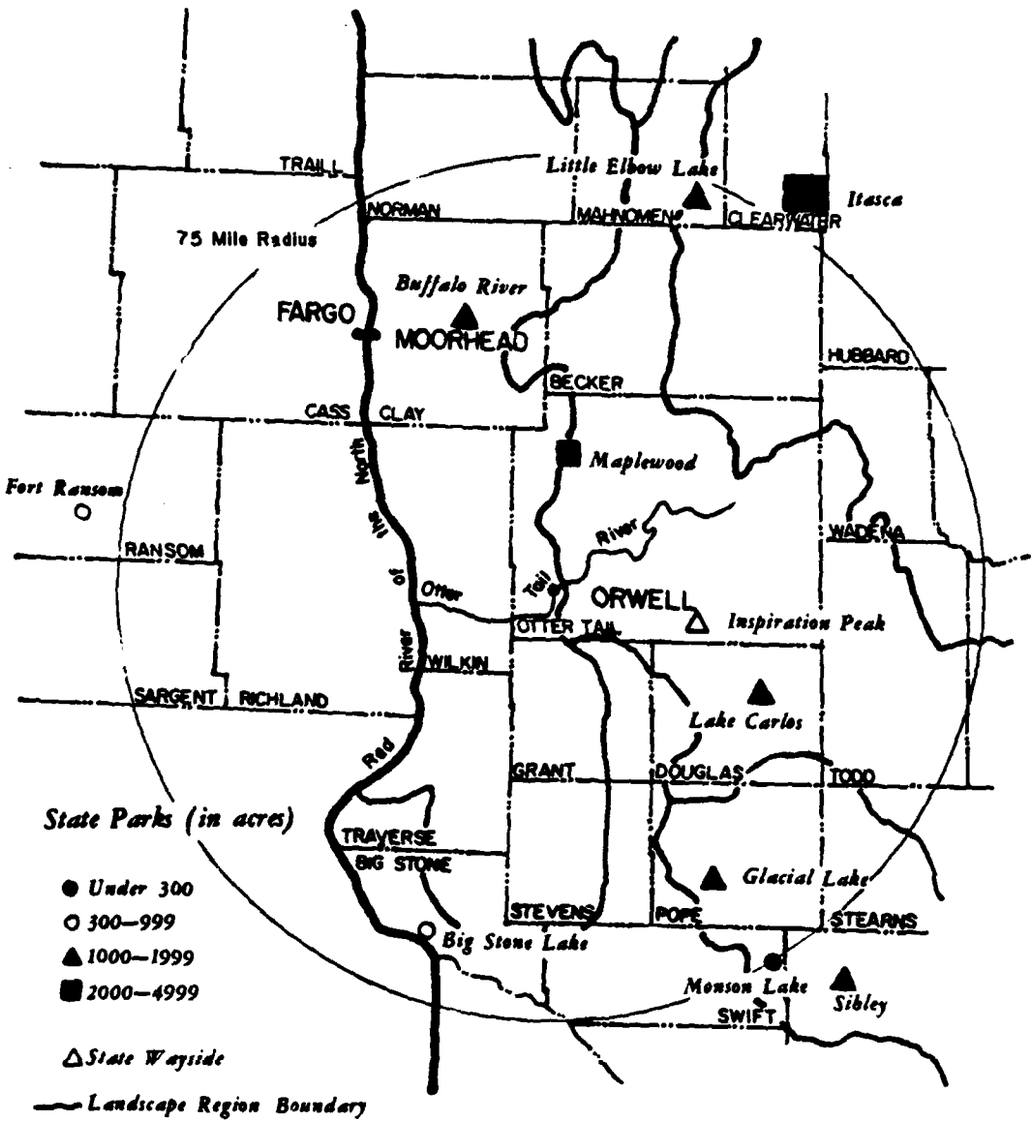


FIGURE 9

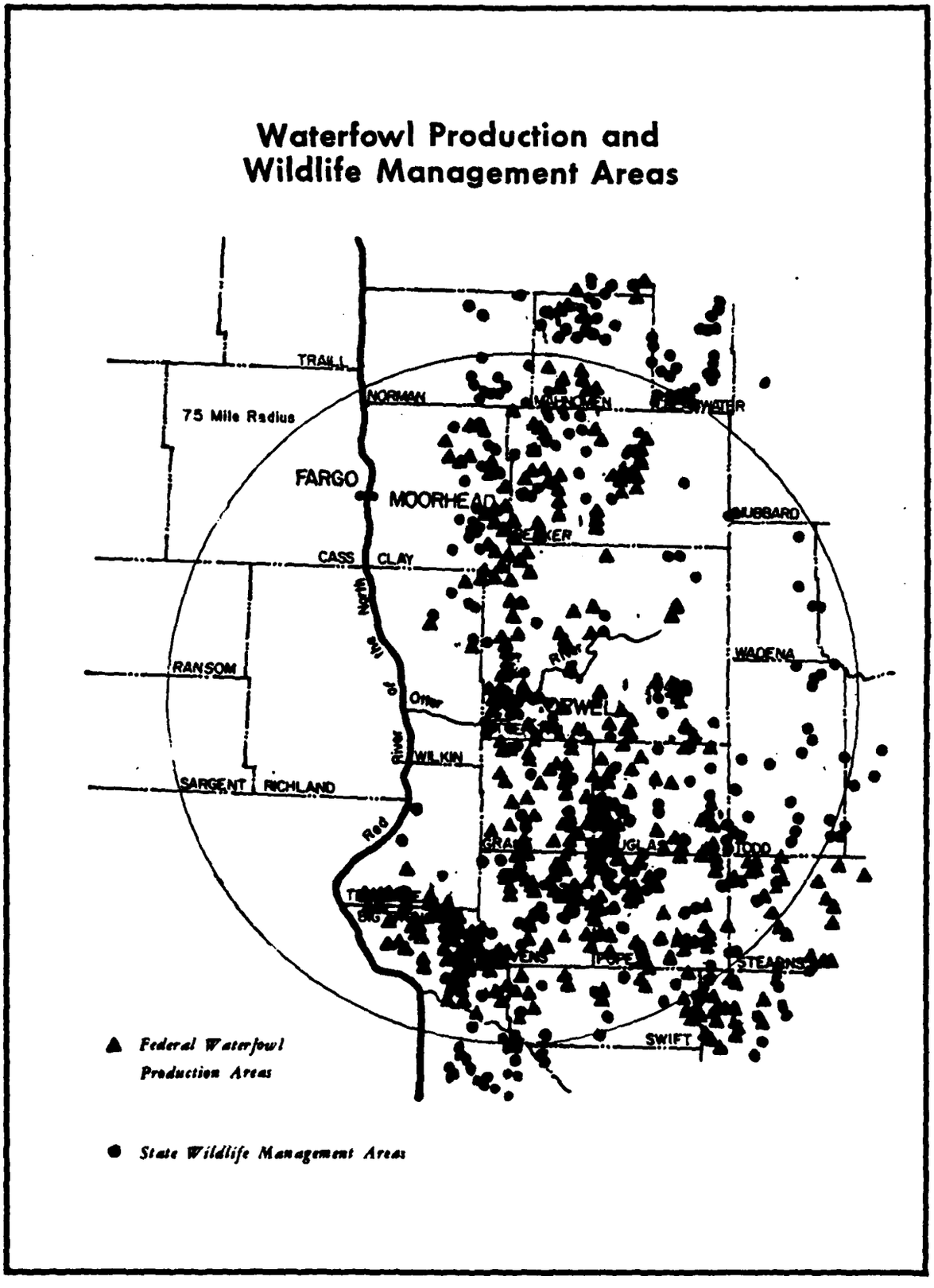

Waterfowl Production and
Wildlife Management Areas
TRAILL
NORMAN
75 Mile Radius
FARGO
MOORHEAD
HUBBARD
CASS
CLAY
RANSOM
WADENA
SARGENT
RICHLAND
WILKIN
SWIFT
▲ Federal Waterfowl Production Areas
● State Wildlife Management Areas

FIGURE 10

The Seven Sisters Prairie and the Otter Tail Prairie near Orwell are the two Nature Conservancy Preserves in Otter Tail County.

Minnesota provides an attractive environment for outdoor recreation because of its unique topography, many lakes, and forests. Figure 11 identifies where these scenic resources are located in Minnesota and their relation to Orwell. The diversity of the topography, the lakes, and the forests, combine to produce the scenic quality necessary for an impressive recreational experience.

The Minnesota Department of Natural Resources (MDNR) has produced a report for selecting rivers that show a potential for canoe route development. The Ottertail River is one of the longest rivers considered by the MDNR as a potential canoe route. Measurement of natural/scenic conditions, social indicators, and other criteria provided the information used to identify those rivers that were appropriate for canoe routes. The Ottertail River was considered a second-priority river because of its length, low development potential, low social resource value, and because two cities over 10,000 in population are within 60 miles of the river.

A feasibility study for a canoe trail on the Ottertail River was prepared by WesMin Resource Conservation and Development Association. The objective was to develop recreation areas to improve the economic conditions of Otter Tail and Becker Counties. The feasibility study area examined the Ottertail River between Elbow Lake and the Wilkin County line. The study identified existing public access points, campsites, historic sites, parks, restrooms, water, and picnic areas, and it provided some recommendations for facility development. One recommendation that could contribute to the use of the Orwell Reservoir was to develop a public access near Kennedy Park and the I-94 bridge just west of Fergus Falls. Other access points and recreational facilities in the Orwell Reservoir were included in the report.

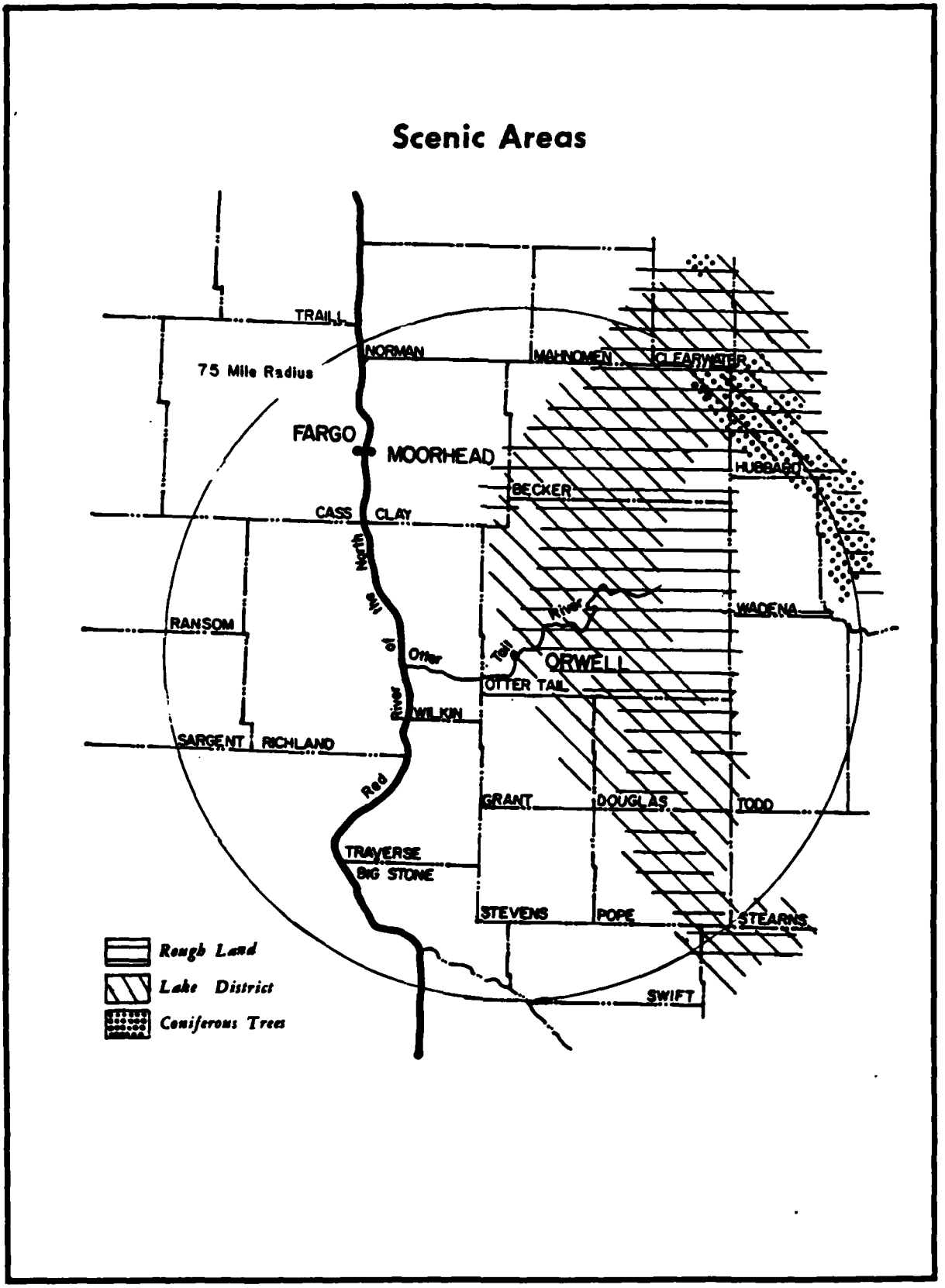

Scenic Areas
75 Mile Radius
TRAILL
NORMAN
MAHNOMEN
CLEARWATER
FARGO
MOORHEAD
HUBBARD
BECKER
CASS
CLAY
North
RANSOM
Otter
Tail
River
ORWELL
WADENA
OTTER TAIL
WILKIN
SARGENT
RICHLAND
Red
GRANT
DOUGLAS
TODD
TRAVERSE
BIG STONE
STEVENS
POPE
STEARNS
SWIFT
Rough Land
Lake District
Coniferous Trees

FIGURE 11

Further evaluations of water depths, obstacles, and snags, and of suitable access points, campsites, and rest areas are needed to determine canoeing opportunities in the Orwell area.

Review of Land Use Maps

The photographs of the land use maps in the evaluation section of this report provide information on present land uses that would be compatible with recreational activities. The land use maps identify forest, cultivated, water, marsh, pasture/open, and urban non-residential or mixed residential land uses on the Ottertail River from Breckenridge to Fergus Falls. These maps were used to obtain a general description of natural and scenic conditions for evaluating the potential of recreational opportunities.

Upstream on the Ottertail River from Breckenridge to Fergus Falls, the land uses change dramatically approximately 14 miles southeast of Breckenridge. The variety of open/pasture, forested, cultivated, urban, and marsh land changes to a majority of cultivated land, limiting natural and scenic resources. Cultivated land use continues upstream along the Ottertail River to approximately 5 miles below the Orwell Dam, where the pattern changes to open/pasture, forest, and cultivated land. From the Orwell Dam and continuing upstream approximately 3 miles above the Dayton Hollow Reservoir, open water is surrounded by open/pasture land, and is scattered with marsh areas. Above the Dayton Hollow Reservoir, the land along the Ottertail River becomes more forested, with patches of open/pasture. The Pelican River, which flows into the Ottertail River, contains mostly forested land with limited areas of open/pasture land.

The scenic diversity that contributes to a high quality recreational experience along the Ottertail River occurs near Breckenridge, below the Orwell Dam, and continues upstream to Fergus Falls, and into the Pelican River.

Recreational Demand

Needs, desires, participation, age, and population will create recreational demand. According to the 1985 Minnesota State Comprehensive Outdoor Recreation Plan, the following recreational activities rank highest for Minnesota's Region 4 needs and desires (in order):

1. Interpretive facilities (historical, nature study, botanical or zoological gardens) and natural park-like areas.

2. Upland game and waterfowl hunting (demand for Region 4 is greater than the State-wide demand).

3. Trail facilities (hiking, walking, canoeing, bicycling, and cross-country skiing).

4. Water-related activities (river accesses, fishing piers, swimming beaches, campgrounds, boat launches, and picnic areas).

The Orwell Reservoir is in a future projected high-demand area for the following activities (in order):

1. Hunting, driving for pleasure, and picnicking.

2. Camping, hiking, and fishing.

3. Bicycling, visiting historical sites, swimming, tennis, and baseball/softball.

4. Canoeing.

In North Dakota's Region 5 (within the 75-mile project area), waterfowl hunting and deer hunting are the two most popular recreational activities participated in, as identified by the Lake Agassiz Inventory

Guide to Outdoor Recreation Needs for North Dakota. Region 5 includes the counties of Sargent, Cass, Richland, Ransom, and Traill. Richland and Ransom Counties have the most public hunting acres available in Region 5, but many North Dakota hunters go elsewhere in the State, or to Minnesota, where the proper topography and other natural physical features are available. Most North Dakota recreational participants also travel to Minnesota for cross-country skiing, powerboating, waterskiing, sailing, and swimming.

Because of the scarcity of resources in North Dakota Region 5, either the Sheyenne River Valley - with its unique quality of heavily forested hills, diverse vegetation, and meandering rivers - will carry the burden of increased user pressures, or many people will continue to travel to other areas, such as Minnesota.

Participation in many recreational activities varies significantly with age. Examination of the changing age structure will influence future recreational patterns. It is worth noting that the population of Fergus Falls (12,519) is evenly distributed among all age groups.

Population growth indicates that major cities (over 10,000 in population) within 75 miles of a recreational opportunity can contribute greatly to recreational use. The following populated areas within 75 miles of the Orwell Reservoir could be considered a possible draw for recreation:

City/Town	Population (1980)	Within Miles
Fergus Falls, Minnesota	12,519	10
Detroit Lakes, Minnesota	7,106	50
Alexandria, Minnesota	7,606	50
Moorhead, Minnesota	29,998	52
Fargo, North Dakota	61,383	60
Wahpeton, North Dakota	9,064	30
Breckenridge, Minnesota	3,900	25

It is assumed that people who live in counties with ample opportunities for recreation would not leave unless they were pursuing activities in short supply. Supply and demand determine how far people are willing to travel for recreation.

Other influencing characteristics on recreational development that contribute to outstanding river or lake values include natural systems, scenic quality, historic sites, and scientific value.

Existing Recreational Resources

Fergus Falls, within 10 miles of Orwell, has been designated as an All-American City; Tree City, U.S.A.; and Star City. Tourism is actively promoted in Fergus Falls. One of the key attractions for promoting tourism is the Otter Tail County Historical Museum. The museum offers a car tape tour (2 to 3 hours) as a guide to many important sites on the east side of town. The Orwell Dam is not included in this car tape tour.

Five lakes, providing over 500 acres of parks, are located mostly along the Ottertail River throughout the city. These parks provide areas for walking, hiking, biking, boating, swimming, camping, fishing, golfing, tennis, softball, track, playgrounds, gardens, skating, skiing, sledding, and snowmobiling. Figure 12 on the following page identifies each park and the activities provided there.

Camping is available within the Fergus Falls city limits, at DeLagoon Park, but this camping area lacks shade, pad space, picnic tables, and grills. Indications are that the area is not used as often as it could be. Many other campsites are available on lakes outside the city limits to the northeast, east, and southeast of the city. Few camping facilities are available to the northwest, west, or southwest of Fergus Falls. Orwell lies southwest of Fergus Falls.

Park Name	Acreage	Baseball	Basketball	Bike Trail	Boating	Camping	Fishing	Flower Garden	Golf	Hockey	Horseshoe	Ice Skating	Nature Area	Picnic Area	Playfield	Play Equipment	Restrooms	Sliding	Softball	Skiing	Snowmobiling	Swimming	Tennis	Trap Shooting
Van Dyk Park	2.9							■						■		■	■							
T.H. Johnson (Athletic)	2.9		■											■	■	■		■	■				■	
W.L. Burnap (Broadway)	3.5											■		■	■	■	■	■						
Lake Alice	6.19				■			■				■					■	■						
Roosevelt	9.8												■	■	■	■	■	■						
Northeast	12.62												■	■		■	■	■			■			
Broken Down Dam	11.												■	■	■	■	■							
DeLagoon	192.	■		■	■	■	■						■	■	■	■	■	■				■		
Pebble Lake	152.			■	■		■		■				■		■	■	■	■				■		■
Adams (Grotto)	20.				■					■		■	■			■	■	■						
Whitford Wildlife Area	2.62									■		■	■	■	■	■	■							
N.P. Park & Tennis Ct.	2.8												■	■	■	■	■						■	
Old Smokey Ski Hill	13.09											■	■					■		■				
Kennedy	52.																							
Robert Hannah (Riverside)	4.35	■	■		■		■						■	■	■	■	■	■	■					
George B. Wright	2.06							■					■											
City Hall	.26							■					■	■			■							
Veterans' Memorial	1.44							■					■	■										
Riverview Waterfowl	4.68												■											

FIGURE 12 - Activities Provided at Parks Along Ottertail River

Many damsites are available in the Fergus Falls area for use by the public. The most popular and accessible operating damsite is Central Dam, located in the middle of the business district. Figure 13 shows the levee behind the dam that provides fishing and viewing of hundreds of ducks and geese. Another popular area for tourists (not an operating damsite) is "Broken Down Dam" at the east edge of Fergus Falls where

FIGURE 13 - Levee Behind Central Dam in Fergus Falls, Minnesota

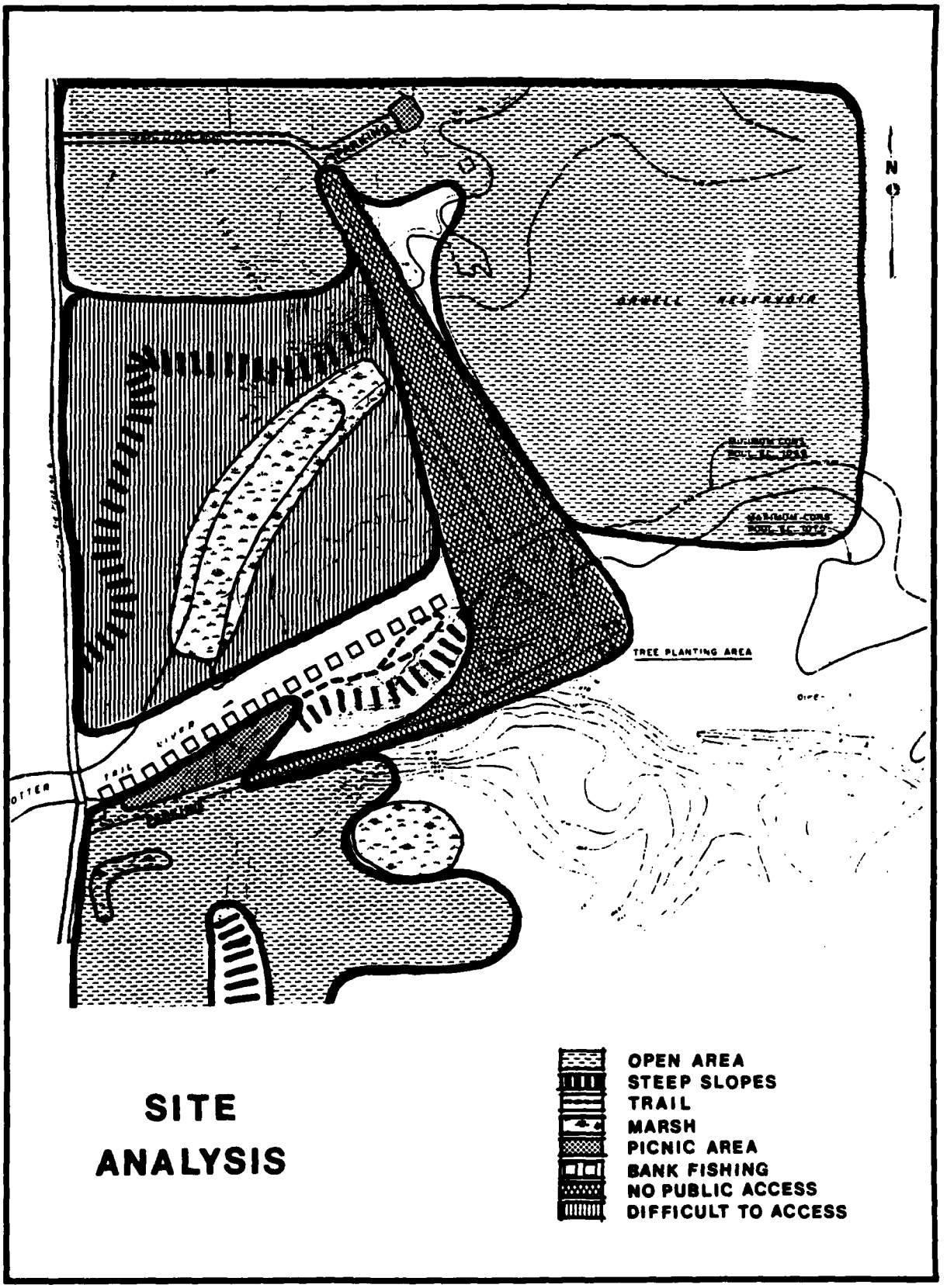

PARKING
N
TREE PLANTING AREA
OTTER
TRAIL
SITE
ANALYSIS
OPEN AREA
STEEP SLOPES
TRAIL
MARSH
PICNIC AREA
BANK FISHING
NO PUBLIC ACCESS
DIFFICULT TO ACCESS

FIGURE 14

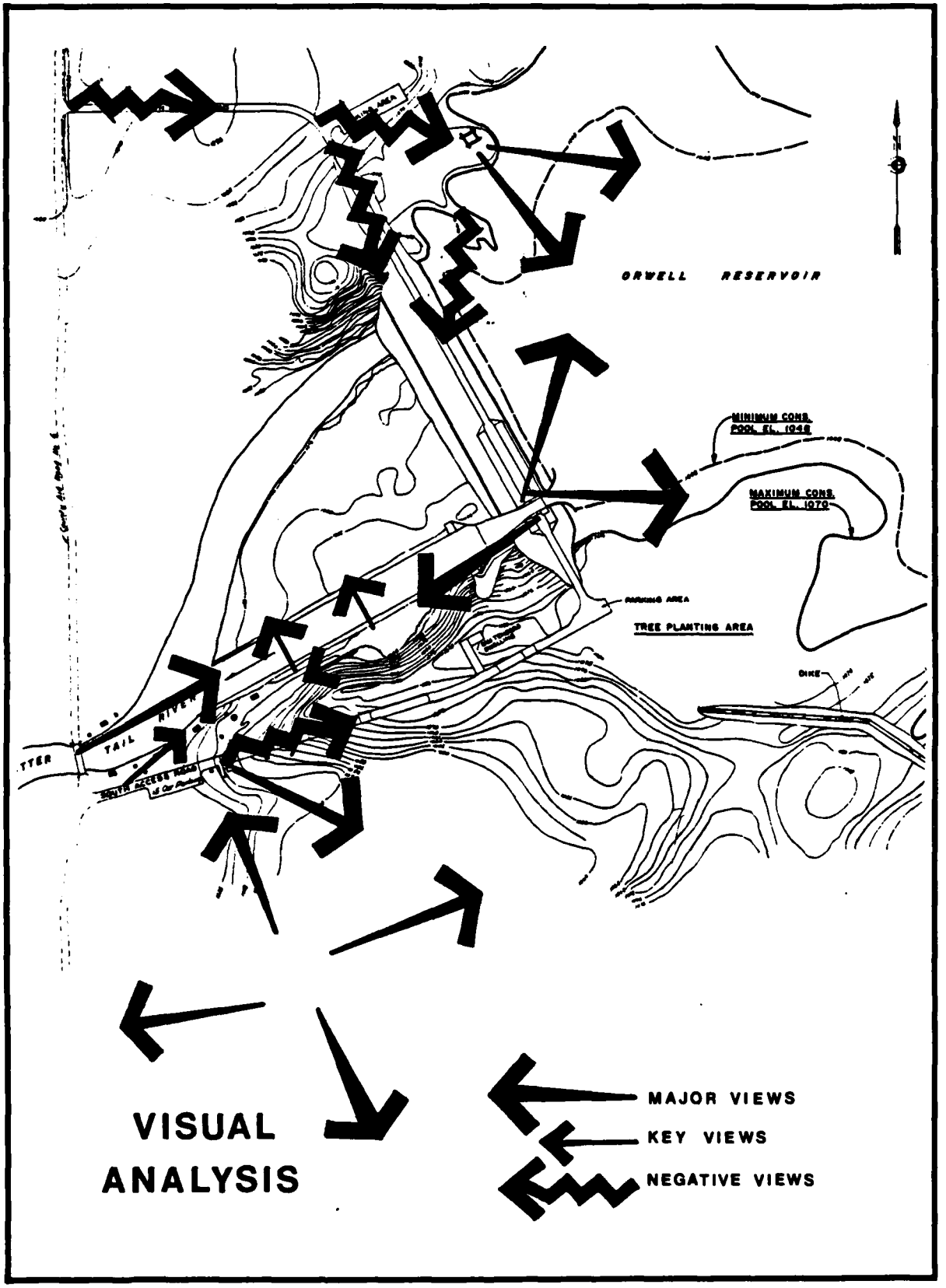

ORWELL RESERVOIR
MINIMUM CONS. POOL EL. 1048
MAXIMUM CONS. POOL EL. 1070
TREE PLANTING AREA
DIKE
TAIL RIVER
VISUAL ANALYSIS
MAJOR VIEWS
KEY VIEWS
NEGATIVE VIEWS

FIGURE 15

picnicking and hiking are available. The Friberg Dam, 8 miles north of the city, is unimproved but provides a pristine setting. Hoot Lake Dam, east of the city, provides a small park, boat launch, and picnic tables. Dayton Hollow Dam, 4 miles southwest of the city, is difficult to access, but wheel ruts from oxcart trails are visible a few hundred yards south of the dam. Pisgah Dam, west of the city, is barely accessible.

The Orwell Dam site is noted as being on the National Register of Historic Places and under Points of Interest in the 1985 Otter Tail Visitors guide and in the Otter Tail Country brochure. Orwell provides picnicking, fishing, hunting, restrooms, grills, and drinking water.

Site and Visual Analysis

During the Orwell site visit, a site analysis and visual analysis was completed. This should be useful in identifying where future improvements or recreational facilities can be located. The site analysis (see Figure 14 on page 49) provides a general guide to the existing physical constraints and recreational opportunities at the Orwell Reservoir. Figure 15 on the previous page identifies major views, key views, and negative views.

Major Views are distant views that offer a dramatic or complementary relationship between aspects of dominance, diversity, continuity, and scale, while balancing elements of form, line, color, and texture. An example of a major view (Figure 16) shows the broad, dynamic view that is available from the Orwell Dam. On-site and off-site views are available from this vantage point.

FIGURE 16 - "Major View"

Key Views are more enclosed views that contain a complementary relationship between the aspects of dominance, diversity, scale and continuity; with a balance of the visual elements of form, texture, line and color. Figure 17 shows an example of a contained view of the Ottertail River within the picnic area. These views are as important as major views but are contained within the site.

FIGURE 17 - "Key View"

Negative Views are unattractive views that lack a balanced relationship of visual elements, and give confusing messages to the visitor. Figure 18 shows an example of a visually disturbing hodgepodge of signs at the entrance to the north access road.

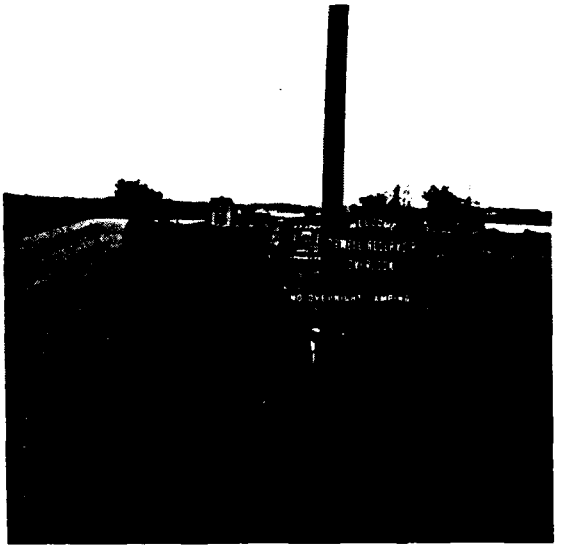


FIGURE 18 - "Negative View"

Factors Affecting Recreational Development at Orwell Reservoir

1. The present fluctuating water level in the Orwell Reservoir makes it undesirable to provide and maintain water-based recreational activities.

2. The Orwell Reservoir is in an area that covers a major concentration of first- and second-priority wetlands for preservation and the majority of project lands are presently being managed for wildlife purposes.

3. The Orwell Reservoir is near major corridors (Interstate 94, Ottertail River, North Country Hiking Trail proposal) and the city of Fergus Falls.

4. The Minnesota Department of Natural Resources received a request from the Otter Tail County Planning Commission that the Ottertail River not be considered for a State canoe trail.

5. The scarcity of recreational resources in North Dakota's Region 5 brings more users to Minnesota.

6. The hunting demand for Minnesota's Region 4 is greater than the State-wide demand.

7. Diverse, scenic, and natural physical resources along the Ottertail River provide an attractive environment for outdoor recreation.

8. Historical and cultural points of interest near Fergus Falls contribute to recreational opportunities.

9. The Otter Tail County Tourism brochure promotes the Orwell Dam as an important point of interest for recreationalists.

10. Current reservoir pool operations hinder wildlife and fishery management, which in turn, limits recreational hunting and fishing opportunities.

11. Access to the Orwell Reservoir via Highway 1 from Interstate 94 does not give visitors a positive visual impact when they are traveling to the site.

12. Shoreline erosion problems at the Orwell Reservoir need to be minimized or eliminated to improve the aesthetics of the area if it is to be developed for recreationalists.

13. Split recreational sites, offering somewhat similiar recreational facilities, do not take advantage of major views, lack a principal entry zone, and do not provide pedestrian or vehicular linkage within the site.

14. The river's edge downstream of the Orwell Dam is difficult to access and to use safely for bank fishing.

15. Signage on both sites obliterates the welcome, pleasant experience that visitors expect.

Desired Reservoir Operation from Recreation Needs Perspective

The recreation resources that are signficantly affected by the Orwell Reservoir operation must be separated into two areas. The recreational area below the dam is dependent on the reservoir releases during the recreational boating season. The MDNR is currently evaluating the potential of developing recreational boating use of the Ottertail River downstream of Orwell Reservoir. The desirable reservoir operation would provide a minimum discharge of at least 80 cfs up to less than the bank-full flow during the recreational boating season. Also, the discharge should remain fairly stable and not change rapidly. Alternative 9 would provide the largest supplemental flows for downstream boating during the

boating season. The tailwater fishing site provided by the Corps is popular with local sportsmen.

The second group of recreation resources involves activities that would be located on the reservoir pool. These activities would be water-based and are best supported by a reservoir operation that provides a stable target pool elevation during the recreation season. Alternative 1 would provide the most stable target pool at elevation 1068. The revegetation program would also improve the visual quality of the shoreline erosion area along the length of the reservoir.

HYDROPOWER POTENTIAL

The Orwell Dam was considered during the National Hydropower Study conducted by the Corps in 1978. During that simplified and preliminary evaluation, a hydropower project at Orwell Dam was determined to be infeasible. A 1.6-megawatt unit was considered, using the flows from the reservoir as they were released under the existing operating plan. Later, the St. Anthony Falls Hydraulics Lab in Minneapolis, Minnesota, reevaluated the site using slightly different assumptions concerning the operating plan. The lab found that if the 22-foot pool fluctuation that presently occurs could be eliminated and if the pool could be stabilized near the normal full pool (1070), then there might be sufficient head enough of the time that a small hydropower unit might be marginally feasible.

The Orwell Problem Appraisal Report, dated February 1985, indicated that this ROPE report would contain a reconnaisance level evaluation of hydropower at Orwell Dam if a new, more stabilized, pool operation was recommended. A reservoir operating plan with more stable and higher pools is being recommended for testing. Such a plan is more conducive to hydropower development than the existing operating plan is. However, there has been a recent Federal water resource policy change concerning development of hydropower at Federal projects by the Federal Government. Briefly, the policy states that because of fiscal constraints it is not

in the Federal interest to develop hydropower at sites where it may be reasonable for non-Federal interests to invest in hydropower. Thus, it was determined that it is probably not in the Federal interest to invest Federal dollars in a reconnaissance-level hydropower investigation of this site.

Any non-Federal proposal for hydropower at Orwell Dam must satisfy the Federal Energy Regulatory Commission (FERC) licensing process. The FERC licensing process includes a technical review by the Corps of Engineers to determine whether the non-Federal hydropower proposal is consistent with the authorized purposes of flood control and pollution abatement and the existing recognized purposes of recreation and fish and wildlife. Even though this report indicates that it is not in the Federal interest to develop hydropower at Orwell Dam at this time, a non-Federal developer should not assume that its hydropower proposal is automatically appropriate for the Orwell project. All non-Federal proposals must satisfy a thorough Federal and public review during the FERC licensing process.

Peaking operation for hydropower is not acceptable because the related fluctuations of pool level and discharges are inconsistent with existing authorized and recognized project purposes in the reservoir and downstream in the Ottertail River.

DOWNSTREAM CHANNEL CAPACITY (ZERO-DAMAGE DISCHARGE)

Channel capacity is defined for the purposes of this discussion as the maximum flow rate a channel can pass without causing significant flood damages. More precisely, it is the "zero damage" discharge. Unfortunately, the zero damage discharge is often difficult to determine. It is more a matter of public acceptability than an exact flow rate. The difficulty in determining an exact "bank-full" release from the reservoir is that the discharge at a given point below the reservoir equals the release from the dam plus tributary and ground-water additions. Tributary and ground-water additions can vary widely

on a seasonal basis. Also, ice and seasonal changes in streambed configuration can affect channel capacity. The only solution is to assume that a particular reservoir release will produce an acceptable bank-full flow at all locations downstream.

The past assumption used for the maximum release that the downstream channel could contain involved the capacity of the downstream channelization project that was constructed by the Corps and is maintained by the local project sponsor. The design discharge for the Ottertail River channelization project between river miles 9.7 and 21.1 is 900 cfs.

The 900 cfs design discharge figure is currently used by the St. Paul District Water Control Center as the maximum total release from Orwell Reservoir to prevent induced flood damages in downstream agricultural and urban areas.

PLANNING CONSTRAINTS

Some of the concerns expressed by the public cannot be appropriately expressed as problems, needs, or opportunities. Such concerns are more properly labeled "planning constraints." Planning constraints also include law, national policy, physical constraints, or any other limitations that can be used to refine and guide formulation of alternative solutions to the stated planning objectives. The following list summarizes the planning constraints identified for this study:

A. Rule Curve

1. Below elevation 1048 feet msl has been identified as a conservation pool for basic survival of fish and wildlife at the Orwell project.

2. Spring snowmelt flooding at Wahpeton and Breckenridge has historically occurred the first week of April, plus or minus one week. The second flood peak is usually smaller, but usually occurs after crops have been planted in June.

3. A contractor's report recommends that the pool be kept below elevation 1068 whenever possible to reduce the rate of shoreline erosion.

B. Reservoir Release (Discharge) Constraints

1. The Minnesota Department of Natural Resources (MDNR) recommends certain minimum and optional releases for instream recreation and fish and wildlife habitat needs. The MDNR is developing a computer model to help develop recommendations for seasonal minimum and optimum flows for aquatic life in the Ottertail River. The instream flows in the following table and in Figure 37 on page 114 are MDNR recommendations based on direct observation and professional judgment. These recommendations will be revised as instream flow model results become available.

2. There are certain instream flow needs for recreation on the Ottertail River.

3. Ramp the changes in discharge, if possible, so that large increases or decreases in discharge are not made in a short period of time (see the table on the following page).

4. The MDNR suggests that the operation plan help retain the morphology of the channel by allowing enough larger spring flows to approximate the pre-project conditions. This would move sediments deposited during the previous year, as naturally occurs in all uncontrolled streams. Flood flows in excess of the control of the reservoir should continue to provide this action.

Reservoir Discharge Ramping Rates Recommended
by the Minnesota Department of Natural Resources

Flow Range (cfs)	Tailwater Stage	Discharge
Decreasing Discharge		
≤ 175	0.1 feet/12 hours	32 cfs/12 hours
175 - 300	0.15 feet/12 hours	55 cfs/12 hours
> 300	0.2 feet/12 hours	
Increasing Discharge		
≤ 175	0.2 feet/12 hours	64 cfs/12 hours
175 - 300	0.3 feet/12 hours	110 cfs/12 hours
> 300	0.4 feet/12 hours	

5. Winter release for flood control drawdown (prior to March 10) rates cannot produce a reservoir drawdown rate greater than the existing average rate of about 0.7 feet/week. Experience with downstream ice conditions has established this rate. The 1,200 cfs channel capacity limit may be too high during ice conditions.

6. Spring release for flood control drawdown (after March 10) rates should not produce a reservoir drawdown rate of greater than about 3.0 feet/week. Tha actual constraint is the 1,200 cfs channel capacity.

C. Additional Miscellaneous Constraints:

1. Federal law, State statutes, and local ordinances and regulations, as well as national water resource policy.

2. The physical dimensions of the project limit the useful storage and discharge capacity of Orwell Reservoir. Plate 4 displays this relationship.

3. The existing low-flow outlets and single tainter gate limit the amount of precise control over releases and reservoir pool elevation.

4. Rates and amount of inflow to Orwell Reservoir from Dayton Hollow Reservoir and other related hydrologic constraints.

5. The presence of rough fish in the reservoir limits the value of the aquatic habitat for more desirable fish species.

6. The present discharge capacity of the tainter gate is 20,500 cfs. Additional uncontrolled overflow spillway capacity is being considered for safety purposes.

PLANNING OBJECTIVES

Planning objectives are resource-oriented statements intended to specify problems, needs, and opportunities identified during public involvement. The statements attempt to reflect the events and results that are desired by groups and individuals, as well as those declared to be in the national interest by the Congress or the Executive Branch. The statements attempt to define the problems and opportunities without dictating a narrow range of alternative solutions. The indicator is intended as a ruler or scale to be used to indicate the level of performance that a particular alternative would achieve for that objective. The objective statements are intended to define future desired conditions as well as desired present conditions. The planning objectives are stated as follows:

During the period of analysis (1985-2035):

1. Contribute to the stream fishery, aquatic habitat, recreation opportunities, and other instream flow needs in the Ottertail River below Orwell Dam. The indicator is the average amount of supplemental discharge between July 15 and September 20.

2. Contribute to the fishery and sport-fishing recreation opportunities in the Ottertail River below Dayton Hollow Dam and in Orwell Reservoir. The indicators are the amount of littoral zone in acres and the ultimate value of those acres (low-medium-high).

3. Reduce agricultural and urban flood damage in the Ottertail River floodplain below Orwell Dam. The indicator is average annual dollars of benefits.

4. Contribute to water quality and pollution abatement in the Ottertail River below Orwell Dam and in the Red River of the North downstream to Fargo/Moorhead. This indicator is the amount of average discharge contribution between July 1 and August 31.

5. Contribute to wildlife resources and hunting opportunities associated with Orwell Reservoir. The indicator is the amount of improvement in wildlife (mostly waterfowl) habitat (low-medium-high).

6. Reduce shoreline erosion on Orwell Reservoir and erosion encroachment on surrounding public and private lands. The indicator for shoreline erosion protection is the reduction in the frequency of the pool over elevation 1068.

7. Contribute to protection and preservation of cultural resources on project lands or other areas affected by project operations. This contribution can be measured by the decrease of shoreline erosion.

PLAN FORMULATION

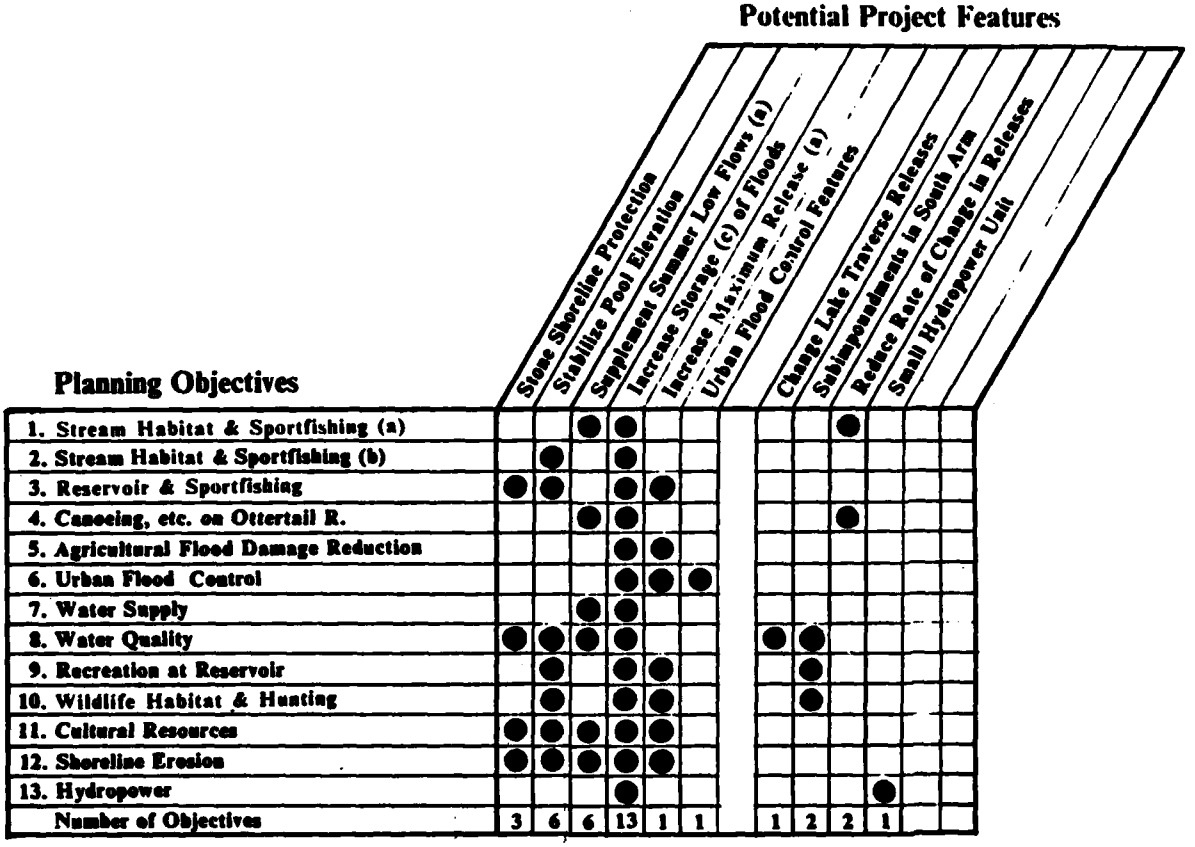
INTRODUCTION

Plan formulation activities began during the initial stages of public involvement and problem identification. In the Orwell Problem Appraisal Report, dated February 1985, potential project features were discussed in conceptual terms for each problem that was identified.

INITIAL PLAN FORMULATION

Figure 19 provides general comparative information concerning the preliminary project features that address the individual planning objectives. Care must be taken when summarizing apparent tendencies in this graphic display because this figure tends to oversimplify the objectives and features. It also does not indicate the magnitude of contributions, nor does it indicate negative effects. The figure leads the reader to believe that increasing upstream storage would provide the most net benefits because these features would contribute to the largest number of objectives. However, the cost and implementability are probably insurmountable for these two potential features, especially under the current fiscal constraints.

Other potential features listed on the figure led to more detailed evaluation and the plan recommended for implementation. These features improve economic or environmental production at the project: (1) more stabilized pool elevation, (2) supplement summer flows rather than winter, (3) increase the assumed channel capacity, and (4) subimpoundment in the south arm of the reservoir for waterfowl management. The two project features of stabilizing pool levels and supplementing summer low flows appeared at the initial stage to hold the most potential for maximizing net benefits while possibly not reducing benefits for the authorized purposes.



(a) On the Ottertail River, downstream from the Orwell Reservoir.

(b) On the Ottertail River, between the Orwell Reservoir and the Dayton Hollow Dam.

(c) In the Ottertail River Basin, upstream of the Orwell Reservoir.

FIGURE 19 - Potential Project Features

Flood Control

It is assumed that the flood control formulation is constrained to using the existing physical project features. This report did not consider construction of additional physical means of providing reservoir storage, such as raising the dam, because of the doubtful feasibility and implementability of such features.

The scope of this effort was confined to evaluating the reservoir operation plan and minor physical features that may greatly improve project performance and benefit. The operation plan formulation consisted of evaluating a range of flood control drawdown elevations.

This evaluation indicated the sensitivity between available storage volumes and corresponding flood control benefits. As shown on the table on page 120 that compares the alternatives, the Orwell project provides less than $15,000 in average annual urban flood control benefits. That amount of average annual benefits is not significant when compared to the agricultural flood damage reduction provided by the Orwell project. Local flood damage reduction features should be considered by Breckenridge, Minnesota.

Channel capacity, also known as the zero-damage discharge, was also considered. The zero-damage discharge used with the existing operation plan is 900 cfs. The alternatives were considered using the same 900 cfs figure. A channel capacity of 1,200 cfs is recommended for the selected operation plan.

Shoreline Erosion

The main proposed change in the reservoir operation that would reduce shore erosion is a lower normal pool elevation (to be changed from 1070 msl to 1068 msl). The proposed reservoir operating plan (alternative 2, page 71) would reduce the duration, height, and frequency of pool surcharge events, thereby reducing the time when pool elevation exceeds 1068 msl, the level recommended by Reid (1984) for reducing shore erosion at Orwell Reservoir.

The MDNR and others have recommended measures to stabilize the eroding banks by grading the banks and placing riprap. This structural means of reducing shore erosion was eliminated from further consideration because of unacceptably high cost (greater than $250,000). The cost is high because of the wide band of rock that would be needed to stabilize the riprap during pool fluctuations.

The eroding faces should eventually attain a stable angle of repose and would revegetate naturally as soon as stable soil conditions allow.

This process may take 15 to 20 years, although it may be accelerated by planting vegetation.

The more gradual base slopes of the eroding banks (see Figure 32 on page 100) should support water-tolerant vegetation as the rate of bank recession (and burial of base slopes) declines. Planting vegetation on these areas would provide protection to the eroding banks during periods of pool surcharge. Erosion of the cut banks will continue by the processes of freeze-thaw, rainfall erosion, and rotational slumping until a stable angle of repose is attained (Reid, 1984). Vegetation will become established on the cut banks as these banks become more stable, further accelerating this stabilization process.

The shore zone of a reservoir with fluctuating water levels is a very stressful environment for most of the plants there. Vegetative stabilization of the base slopes of the eroding banks at Orwell Reservoir requires plants that are perennial, are tolerant of inundation of up to 40 days, have fibrous root systems that will bind the soil and resist wave erosion, are tolerant of some soil burial from the adjoining cut banks, and can be established easily at low cost.

Two species of willow that grow at Orwell Reservoir could be used for bank stabilization plantings. Sandbar willow (Salix interior) and coyote willow (Salix exigua) are multiple-stemmed shrub willows that are very water-tolerant. Both species form dense thickets along streams and lake shores (Froiland, 1962). Salix exigua was observed to survive 44 days completely inundated at Lake Sakakawea (Hoffman, 1978). Salix interior occurs along many midwestern streams, surviving inundation of over 30 days. Both species grow well from cuttings harvested when the plant is dormant.

Cuttings of willow will be taken in March and placed in moist, cool storage until pool surcharge events are no longer anticipated. The willow cuttings will then be planted by simply sticking the cuttings at an angle into the ground, leaving several buds exposed. If a limited-

scale initial effort of willow plantings succeeds, a larger-scale planting effort will be organized for subsequent years, enlisting the aid of volunteer help for harvesting and planting cuttings. Some seedling green ash (Fraxinus pennsylvanica) will also be planted. Green ash is a very water-tolerant (Hoffman, pers. comm., 1986) and fast-growing tree species.

Instream Flow Requirements, Pollution Abatement, and Water Supply

The public involvement results indicated a need to reschedule releases for these purposes to about the period from July 15 to September 20. The existing operation plan stores a portion of the inflow during this period. Thus, it provides a negative contribution to (reduces) the average downstream flows during the time these flows are needed under current and forseeable conditions. A minimum improvement would be to discharge the inflow during this period.

The MDNR provided target discharges for instream flow requirements during the period from July 15 to September 20 as well as all other times of the year. The information is presented in the Planning Constraints section beginning on page 57 and in the Plan Formulation section beginning on page 62. The actual amount released depends on the amount of drop in pool elevation that could be tolerated during that period. Also, if the pool was already higher because of floodwater storage, then a larger drop in the pool would be available. The maximum drop would occur if the pool were drawn all the way down to elevation 1048 msl. However, that magnitude of pool drop during the low-flow season would be very detrimental to the aquatic habitat present in the reservoir and to the fall waterfowl migration and hunting season.

Urban areas downstream are interested in summer low-flow supplemental releases for a variety of purposes as described in the Problems, Needs, and Opportunities section.

The following alternative operation plans were developed to evaluate a range of summer drawdowns for instream needs and other summer low-flow needs. This range of drawdowns also provided an opportunity to evaluate the sensitivity of flood control drawdowns.

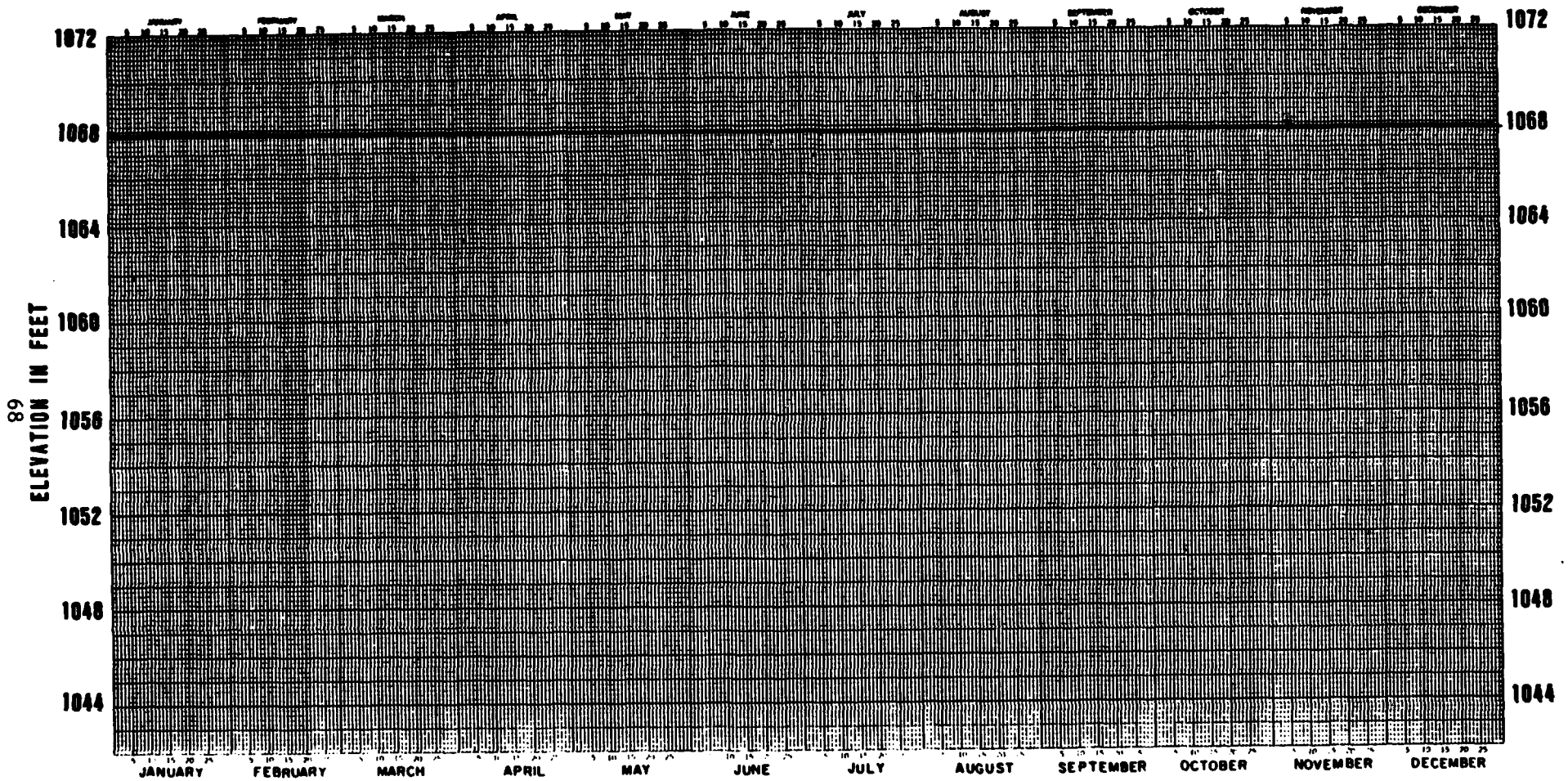
Alternative Operation Plans

The alternative operation plans considered are shown on the following rule curve diagrams and associated table of standing directions to the damtender. The rule curve should be thought of as a set of target pool elevations and not as an exact trace of the pool elevation for every year. For example, a large flood may drive the pool up to elevation 1075, the maximum surcharge elevation. The standing directions to the dam tender indicate the acceptable variations from the rule curve for each alternative.

Alternative 1 is a logical starting point for operation plan formulation. Much of the input from the public indicated that a stable pool would be desirable for wildlife, aquatic habitat, and recreation. The higher the pool would be, the more physical area that would be available for these purposes. However, the shoreline erosion recommendation is to keep the pool at or below elevation 1068 msl. Thus, alternative 1 would keep the pool at that elevation. In contrast to the positive effects mentioned above, this alternative would provide a reduced amount of flood control and instream flow contributions compared to the maximum potential contributions for those purposes.

Alternatives 2, 4, 6, and 8 would provide a range of flood control drawdowns for a check of sensitivity of benefits as previously discussed. Alternatives 3, 5, 7, and 9 would reschedule releases to the period of time when the discharges are valuable for summer instream flow contributions and pollution abatement discharges.

The following diagrams all mention that the channel capacity is 1,200 cfs. An identical set of alternatives were evaluated for flood control benefit, except that a 900 cfs channel capacity was used for comparison.



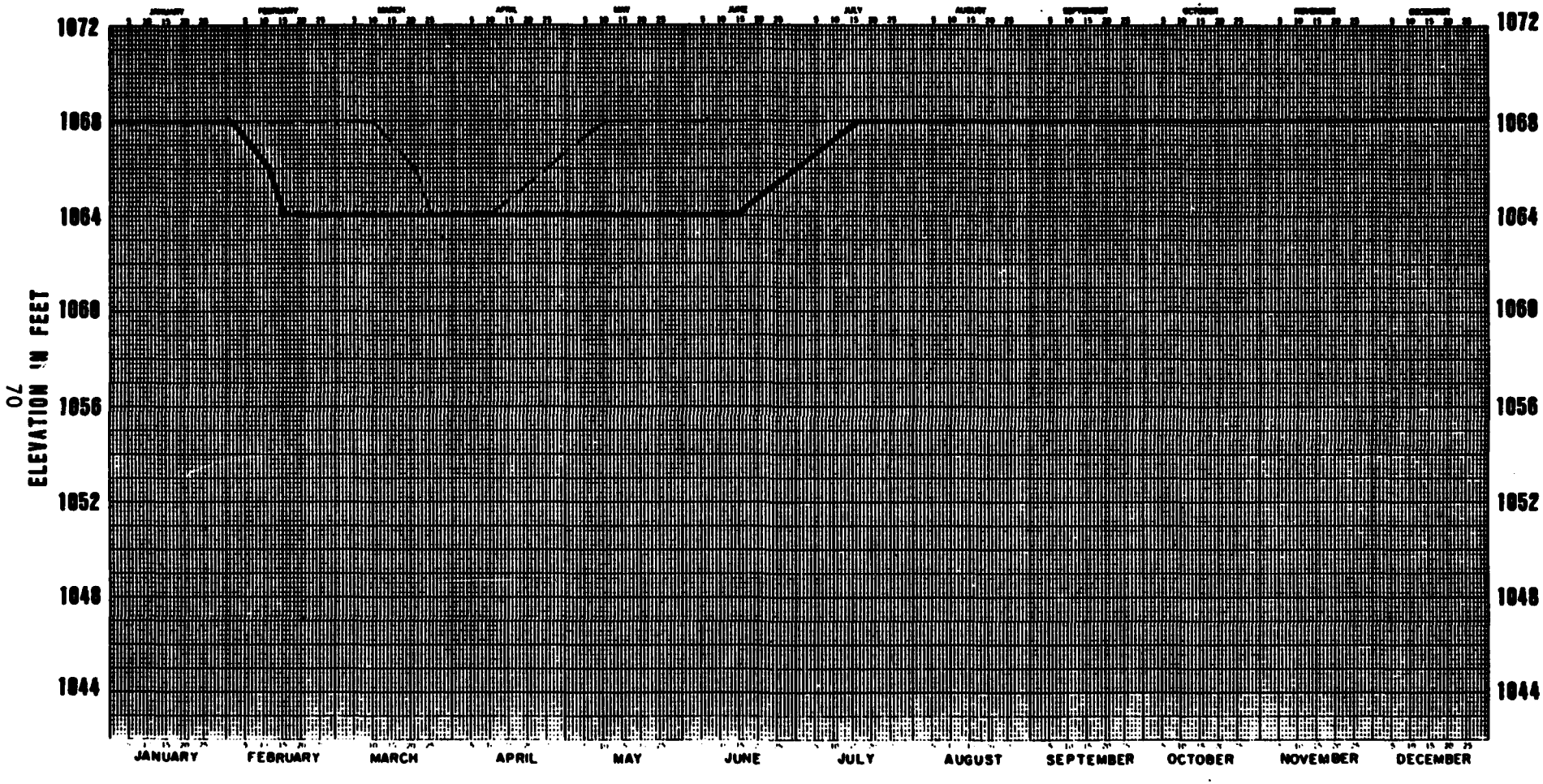
ALTERNATIVE I

FIGURE 20

ALTERNATIVE 1

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1068.0	Winter	During springs when the snow mantle has a normal water content, maintain the normal full pool elevation of 1068.0 msl by releasing the inflow. Continue this operation until the inflow exceeds 1,200 cfs; at that point, begin the flood control operation. During years when hydrologic conditions indicate that significant flooding (over 25-year) would occur, draw down the pool as physical constraints permit, but no lower than elevation 1048.0 msl in any case.
Flood Control			
Spring breakup to about June 15	1068.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached; then surcharging rules will be used. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1068.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1068.0 and the surcharge is disposed of.
		Spring drawdown	If a spring drawdown is needed, draw down the pool to the target elevation of 1068.0 or lower, if needed. Complete it, if possible, by May 15. Most agricultural flooding occurs between May 15 and June 10. Use surcharging rules if that flood control storage is needed. If the drawdown is not needed, return to the normal full pool elevation 1068.0, as soon as possible, while following the rules to dispose of the surcharge.
		Fall and summer floods	Up to pool elevation 1070.0, release up to the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1068.0 and the surcharge is disposed of.
Routine Operation			
About June 15 to September 20	1068.0	Return to normal pool	As soon as the pool returns to elevation 1068.0, maintain that elevation by releasing inflow unless summer or fall floods occur. Minimum normal discharge is 80 cfs and channel capacity is 1,200 cfs.
Drought			
Low water period	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



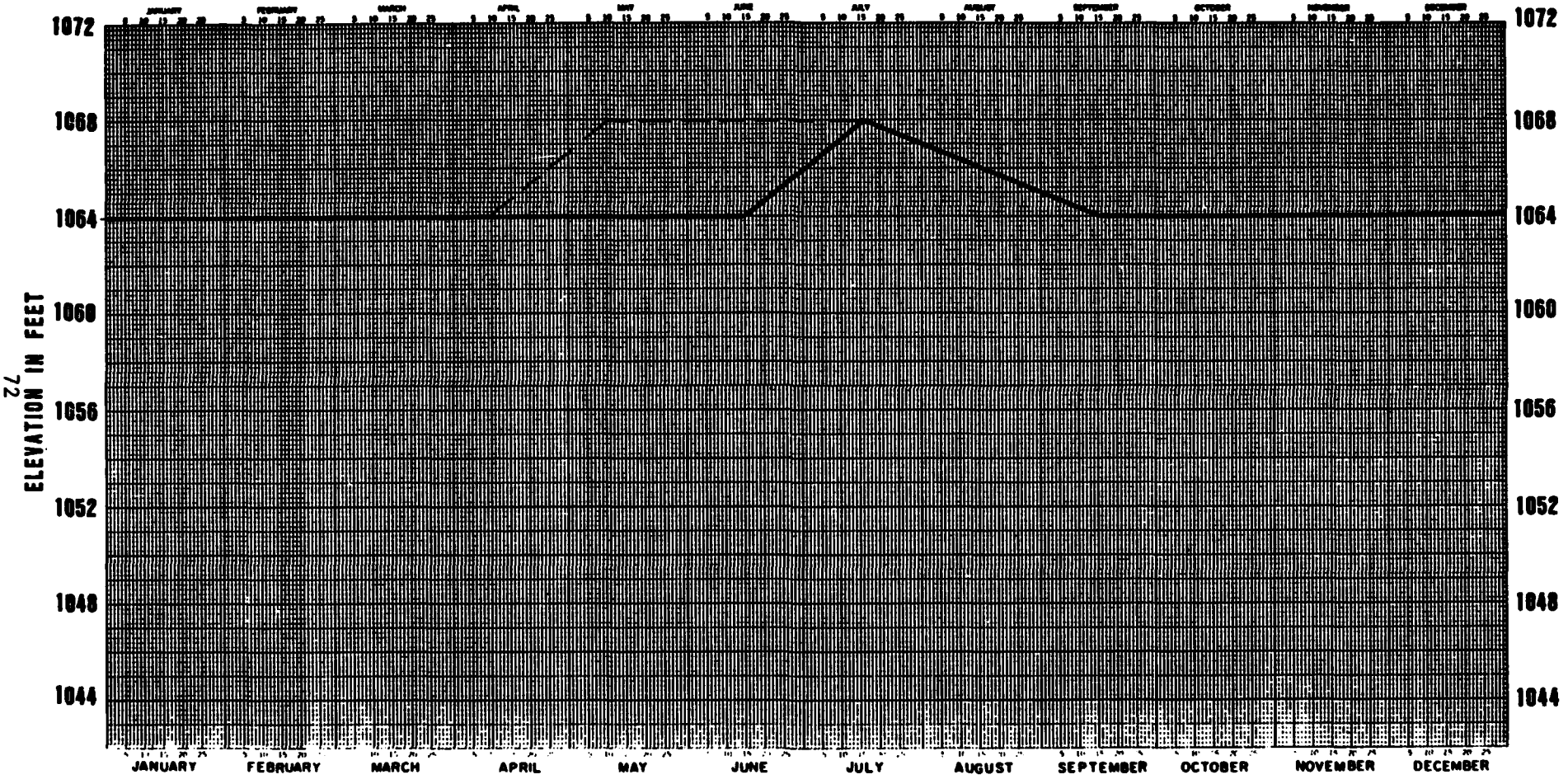
ALTERNATIVE 2

FIGURE 21

ALTERNATIVE 2

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1068.0 to 1064.0	Winter drawdown	Begin the winter flood control drawdown as late as possible to reach the required drawdown elevation by April 1. Urban flood conditions at Wahpeton-Breckenridge typically occur about April 10. Drawdown may not be needed every year, but should begin by March 10, if it is needed. The target drawdown schedule is to begin on March 10 to lower the pool to elevation 1064.0 by April 1. Depending on the predictive capability, decrease or increase the target drawdown elevation to reflect the prevailing hydrologic conditions, but no lower than elevation 1048.0. Reserve adequate storage, if possible, for the spring drawdown for the purpose of agricultural flood control.
Flood Control			
Spring breakup to about June 15	1064.0 to 1068.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Flooding at Wahpeton-Breckenridge is typically a result of snowmelt runoff from areas below Orwell and Traverse Dams. Storing of inflow shall continue if necessary until elevation 1068.0 is reached; then surcharging rules will be used. Channel capacity is 1,200 cfs and flood wave travel time is normally 1 day.
	1068.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1068.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1068.0 and the surcharge is disposed of.
		Spring drawdown	If a spring drawdown is needed, draw down the pool to the target elevation of 1064.0 or lower, if needed. Complete it, if possible, by May 15. Most agricultural flooding occurs between May 15 and June 10. The agricultural flooding is typically a result of snowmelt runoff from areas upstream of Orwell Dam. If the drawdown is not needed, return to the normal full pool elevation 1068.0, as soon as possible, while following the rules to dispose of the surcharge.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1068.0 and the surcharge is disposed of.
Routine Operation			
About June 15 to September 20	1068.0	Filling reservoir	As soon as the pool returns to elevation 1068.0, maintain it by releasing inflow, unless summer or fall flooding occurs. The normal full pool elevation is 1068.0. Minimum normal discharge is 80 cfs, and channel capacity is 1,200 cfs.
Drought			
Low water period	1068.0 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



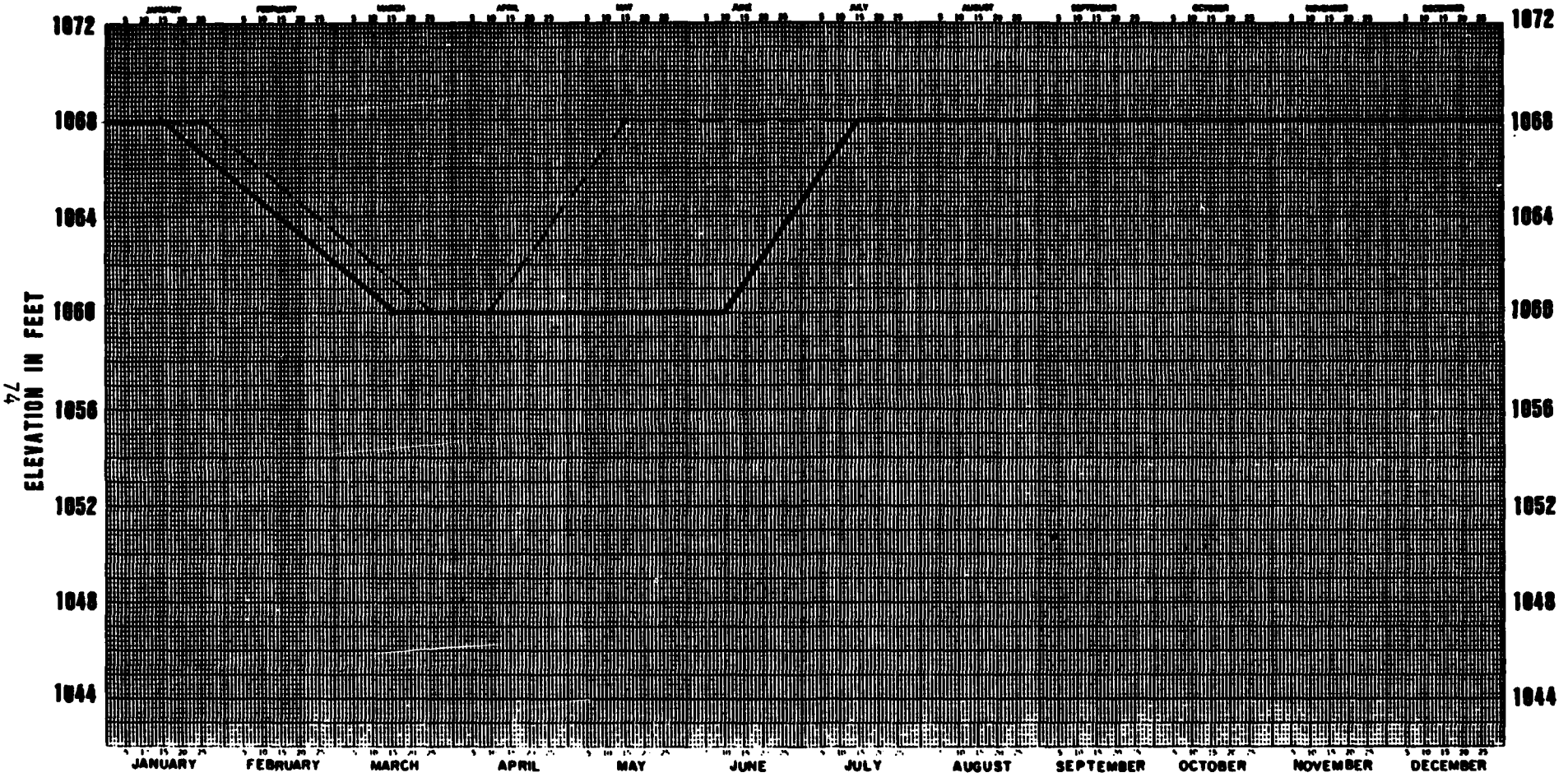
ALTERNATIVE 3

FIGURE 22

ALTERNATIVE 3

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1064.0	Winter	Maintain a normal pool elevation of 1064.0 by releasing inflow. When the inflow exceeds 1,200 cfs, begin flood control operation. During years when hydrologic conditions indicate that significant (over 25-year) flooding will occur, draw down the pool, as physical constraints permit, but no lower than elevation 1048.0 in any case.
Flood Control			
Spring breakup to about June 15	1064.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached; then use the surcharging rules. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1068.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1068.0 and the surcharge is disposed of.
		Spring drawdown	If a spring drawdown is needed, draw down the pool as physical constraints permit, but in no case lower than elevation 1048.0. Complete it by May 15, if possible. Most agricultural flooding occurs between May 15 and June 10. If the drawdown is not needed, return the pool to elevation 1068.0 as soon as possible, while following the rules to dispose of the surcharge and provide a supplement of summer low flows until about September 20.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1068.0 and the surcharge is disposed of.
Routine Operation			
About June 15 to September 20	1064.0 to 1068.0 to 1064.0	Filling reservoir and instream flow supplement	The outflow will equal the inflow plus an average of about 25 cfs supplemental flow between June 15 and September 20 to bring the pool down to normal full pool elevation of 1064.0 on September 20. Channel capacity is 1,200 cfs. Inflows greater than that require operation for flood control. The year-round minimum discharge is 80 cfs and inflows below that require drought operation.
Drought			
Low water period in Red River	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



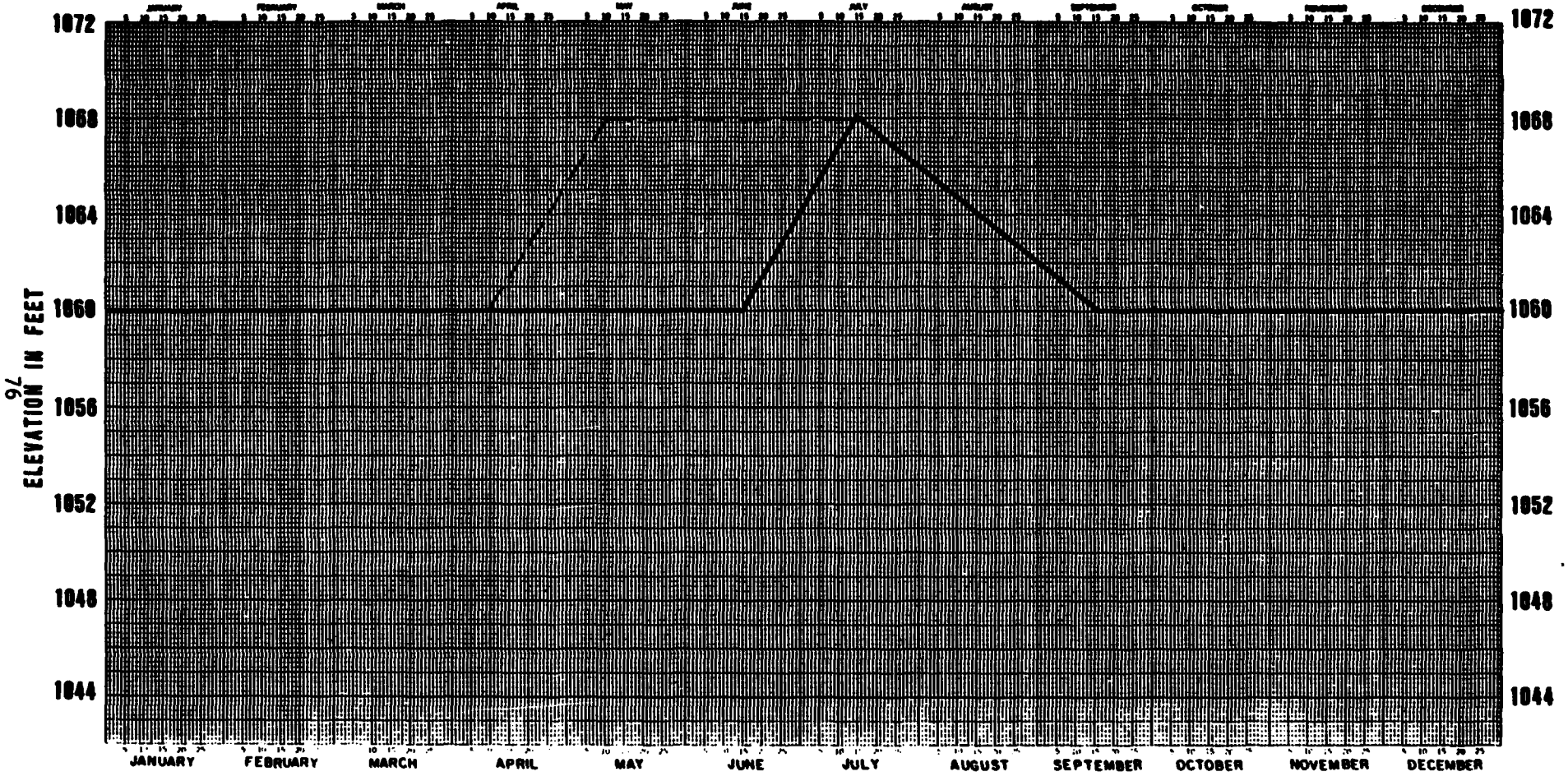
ALTERNATIVE 4

FIGURE 23

ALTERNATIVE 4

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1068.0 to 1060.0	Winter drawdown	Begin the winter flood control drawdown as late as possible to reach the required drawdown elevation 1060.0 by April 1. Urban flood conditions at Wahpeton-Breckenridge typically occur about April 10. Drawdown may not be needed every year, but begin this operation by March 10, if needed. The target drawdown schedule is to lower the pool to elevation 1060.0 by April 1. Depending on the predictive capability, decrease or increase the target drawdown elevation to reflect the prevailing hydrologic conditions, but no lower than elevation 1048.0. Reserve adequate storage if possible for the spring drawdown for the purpose of agricultural flood control.
Flood Control			
Spring breakup to about June 15	1060.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached; then use the surcharging rules. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1068.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1068.0 and the surcharge is disposed of.
		Spring drawdown	If a spring drawdown is needed, draw down the pool to the target elevation of 1060.0 or lower, if needed. Complete it, if possible, by May 15. Most agricultural flooding occurs between May 15 and June 10. If the drawdown is not needed, return the pool to elevation 1068.0 as soon as possible, while following the rules to dispose of the surcharge.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1068.0 and the surcharge is disposed of. Return to rule curve in a reasonable amount of time, if possible.
Routine Operation			
About June 15 to September 20	1060.0 to 1068.0	Filling reservoir	As soon as pool has returned to 1068.0, maintain that elevation by releasing the inflow, unless summer or fall floods occur. Minimum release throughout the year is 80 cfs and channel capacity is 1,200 cfs. Before June 1, a new plate shall be used to obtain data required to fill pool to elevation 1068.0 by July 15.
Drought			
Low water period in Red River	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



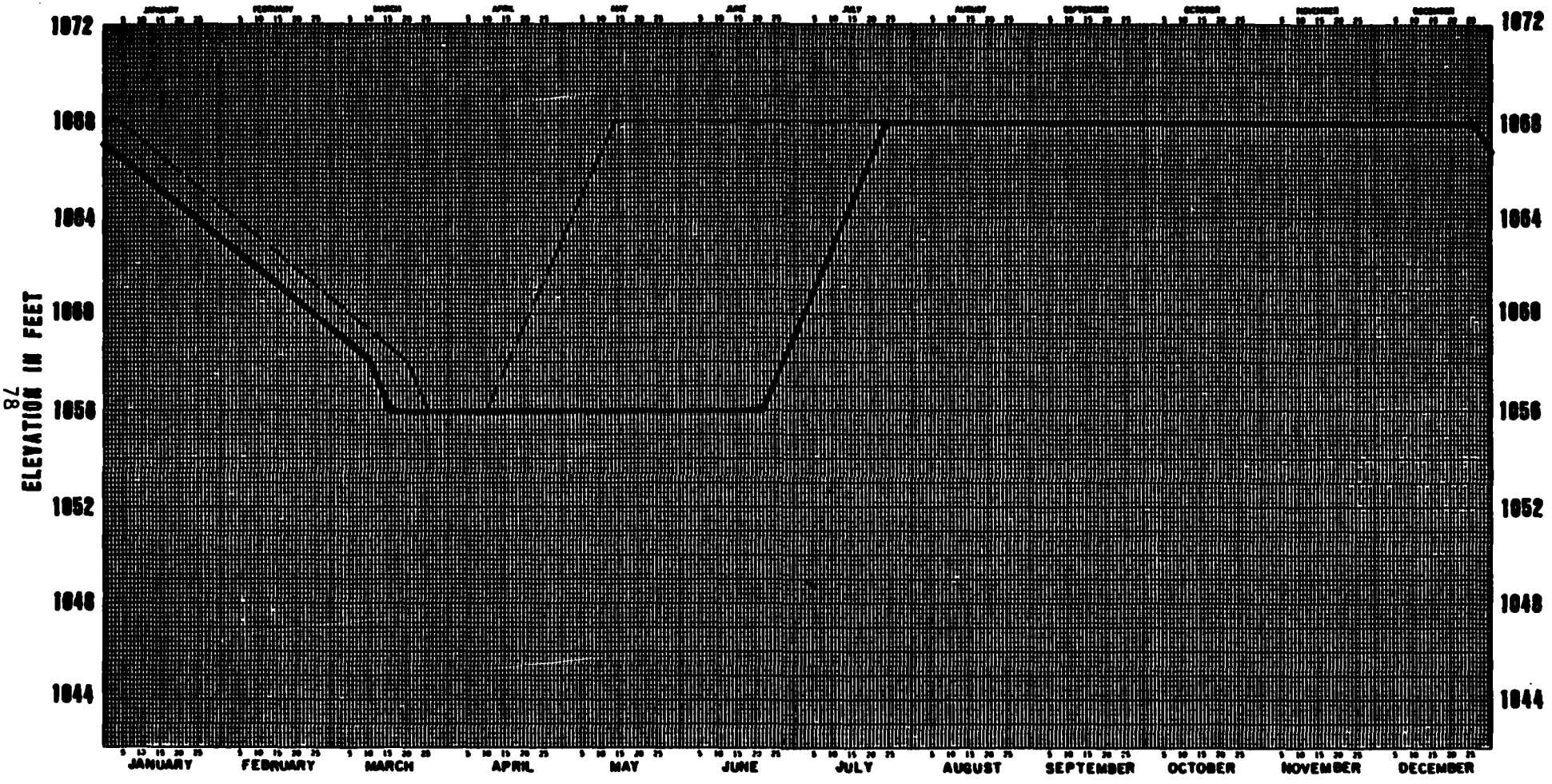
ALTERNATIVE 5

FIGURE 24

ALTERNATIVE 5

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1060.0	Winter	Each year from September 20 until spring breakup, attempt to maintain elevation 1060.0. Outflow should equal inflow. Maximum discharge shall not exceed 1,200 cfs channel capacity, except that downstream channels may be reduced by ice conditions before breakup.
Flood Control			
Spring breakup to about June 15	1060.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1070.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1070.0 and the surcharge is disposed of.
		Spring drawdown	When the pool is below elevation 1070.0 and the stage at Wahpeton-Breckenridge permits, the spring drawdown shall begin, if needed, by discharging up to 1,200 cfs until the pool is lowered to elevation 1060.0, if possible, or lower, if needed. Maintain elevation 1060.0 or lower by discharging inflow until it becomes necessary to begin storing inflow for flood prevention or to begin filling the pool.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1070.0 and the surcharge is disposed of. Return to rule curve in a reasonable amount of time, if possible.
Routine Operation			
About June 15 to September 20	1060.0 to 1068.0 to 1060.0	Filling reservoir and instream flow supplement	Between July 15 and September 20, the pool shall be lowered to 1060.0 to supplement instream flow. Minimum flow year round will be 80 cfs, and the channel capacity is 1,200 cfs.
Drought			
Low water period in Red River	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



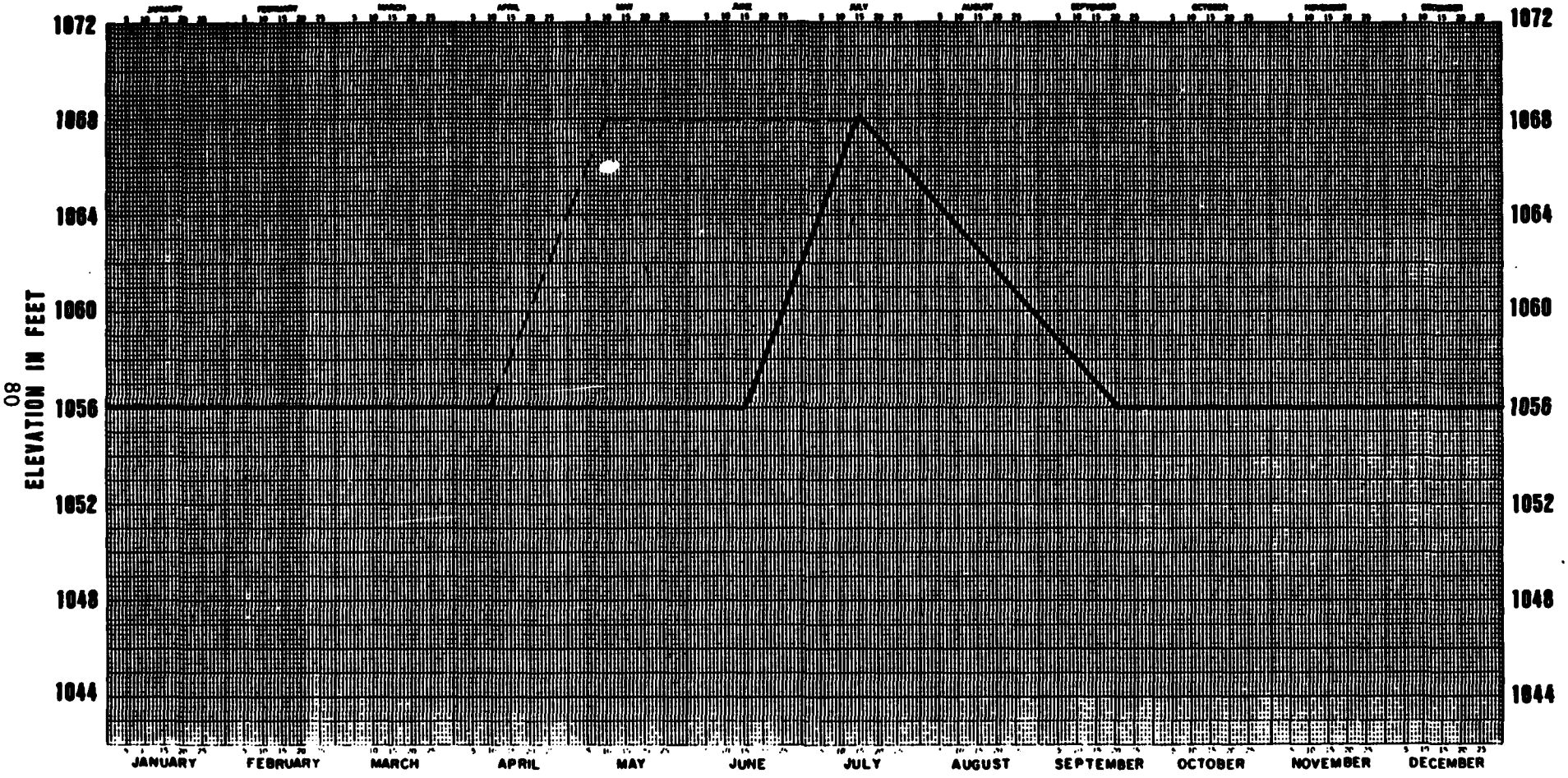
ALTERNATIVE 6

FIGURE 25

ALTERNATIVE 6

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freeseup to spring breakup	1068.0 to 1056.0	Winter drawdown	Begin the winter flood control drawdown as late as possible to reach the required drawdown elevation 1056.0 by April 1. Urban flood conditions at Wahpeton-Breckenridge typically occur about April 10. Drawdown may not be needed every year, but should begin by March 10, if it is needed. The target drawdown schedule to lower the pool to elevation 1056.0 by April 1. Depending on the predictive capability, decrease or increase the target drawdown elevation to reflect the prevailing hydrologic conditions, but no lower than elevation 1048.0. Reserve adequate storage, if possible, for the spring drawdown for the purpose of agricultural flood control.
Flood Control			
Spring breakup to about June 15	1056.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached; then use the surcharging rules. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1068.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1068.0 and the surcharge is disposed of.
		Spring drawdown	If a spring drawdown is needed, draw down the pool to the target elevation of 1056.0 or lower, if needed. Complete it, if possible, by May 15. Most agricultural flooding occurs between May 15 and June 10. If the drawdown is not needed, return to the normal full pool elevation 1068.0, as soon as possible, while following the rules to dispose of the surcharge.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1068.0 and the surcharge is disposed of.
Routine Operation			
About June 15 to September 20	1056.0 to 1068.0	Filling reservoir	As soon as the pool returns to elevation 1068.0, maintain that elevation by releasing the inflow, unless summer or fall flooding occurs. Minimum normal discharge is 80 cfs, and channel capacity is 1,200 cfs.
Drought			
Low water period	1068.0 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



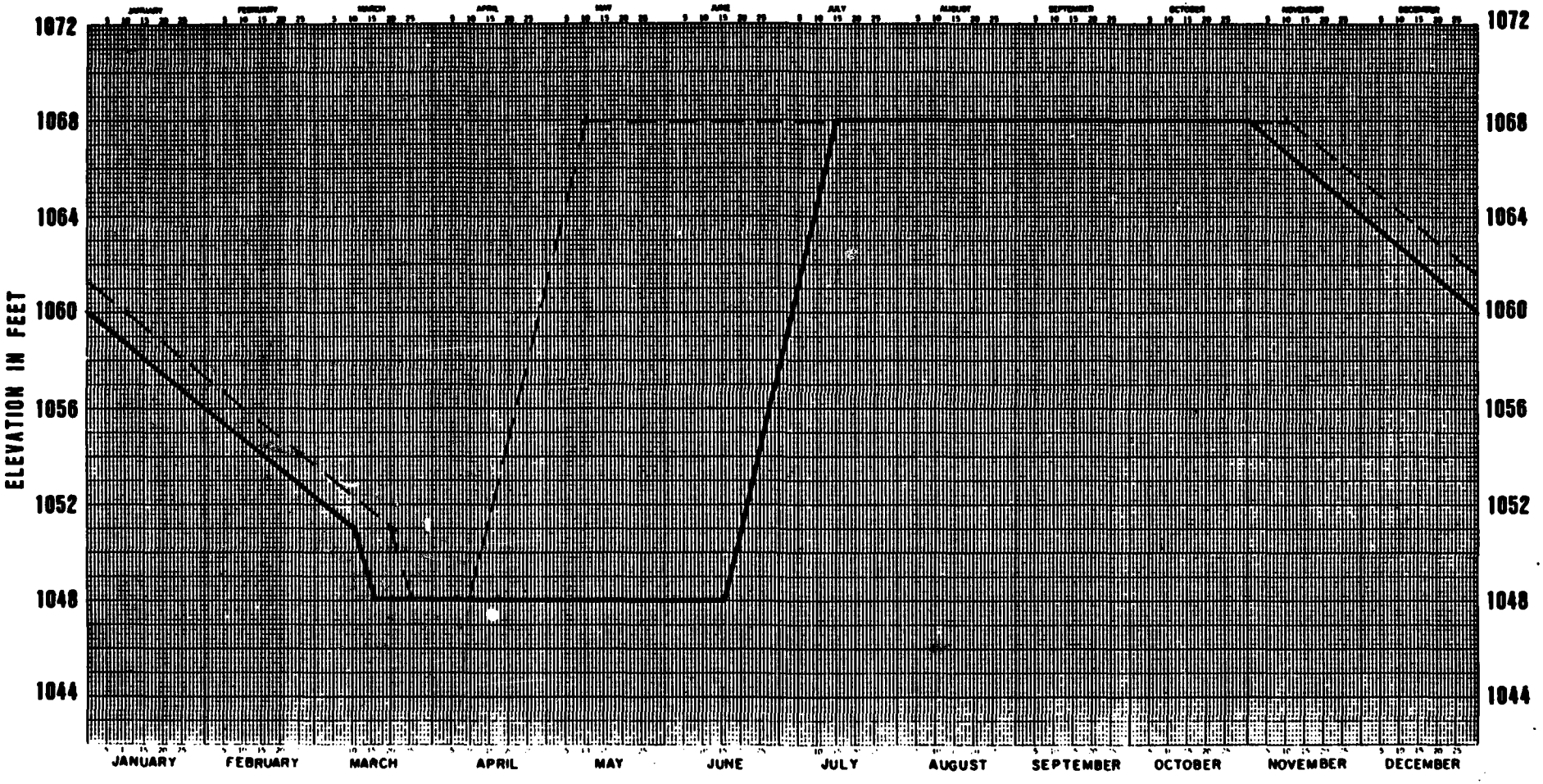
ALTERNATIVE 7

FIGURE 26

ALTERNATIVE 7

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1056.0	Winter	Each year from September 20 until spring breakup, attempt to maintain elevation 1056.0. Outflow should equal inflow. Maximum discharge shall not exceed 1,200 cfs channel capacity, except that downstream ice conditions may reduce channel capacity until breakup.
Flood Control			
Spring breakup to about June 15	1056.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1070.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1070.0 and the surcharge is disposed of.
		Spring drawdown	When the pool is below elevation 1070.0 and the stage at Wahpeton-Breckenridge permits, the spring drawdown shall begin, if needed, by discharging up to 1,200 cfs until the pool is lowered to elevation 1056.0, if possible, or lower, if needed. Elevation 1056.0 or lower, if needed, shall be maintained by discharging inflow until it becomes necessary to begin storing inflow for flood prevention or to begin filling the pool.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1070.0 and the surcharge is disposed of. Return to rule curve in a reasonable amount of time, if possible.
Routine Operation			
About June 15 to September 20	1068.0 to 1056.0	Filling reservoir and instream flow supplement	Between July 15 and September 20, the pool shall be lowered to 1056.0 to supplement instream flow so that it averages 60 cfs plus inflow. Minimum year-round discharge is 80 cfs and the channel capacity is 1,200 cfs.
Drought			
Low water period in Red River	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



ALTERNATIVE 8

FIGURE 27

AD-A167 896 FINAL ORWELL ROPE (RESERVOIR OPERATION PLAN EVALUATION) 2/3
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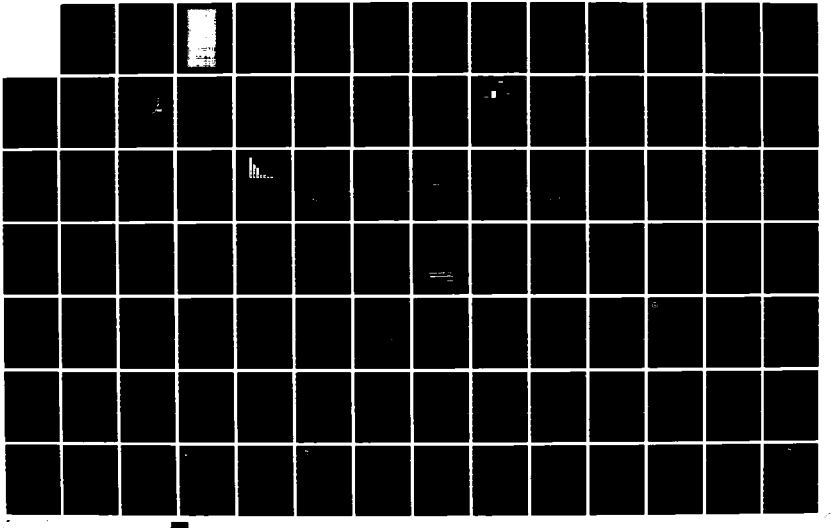
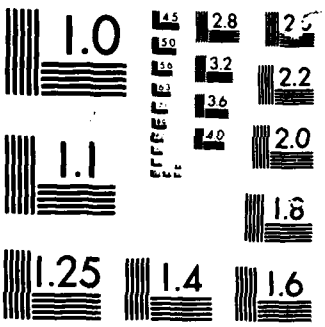
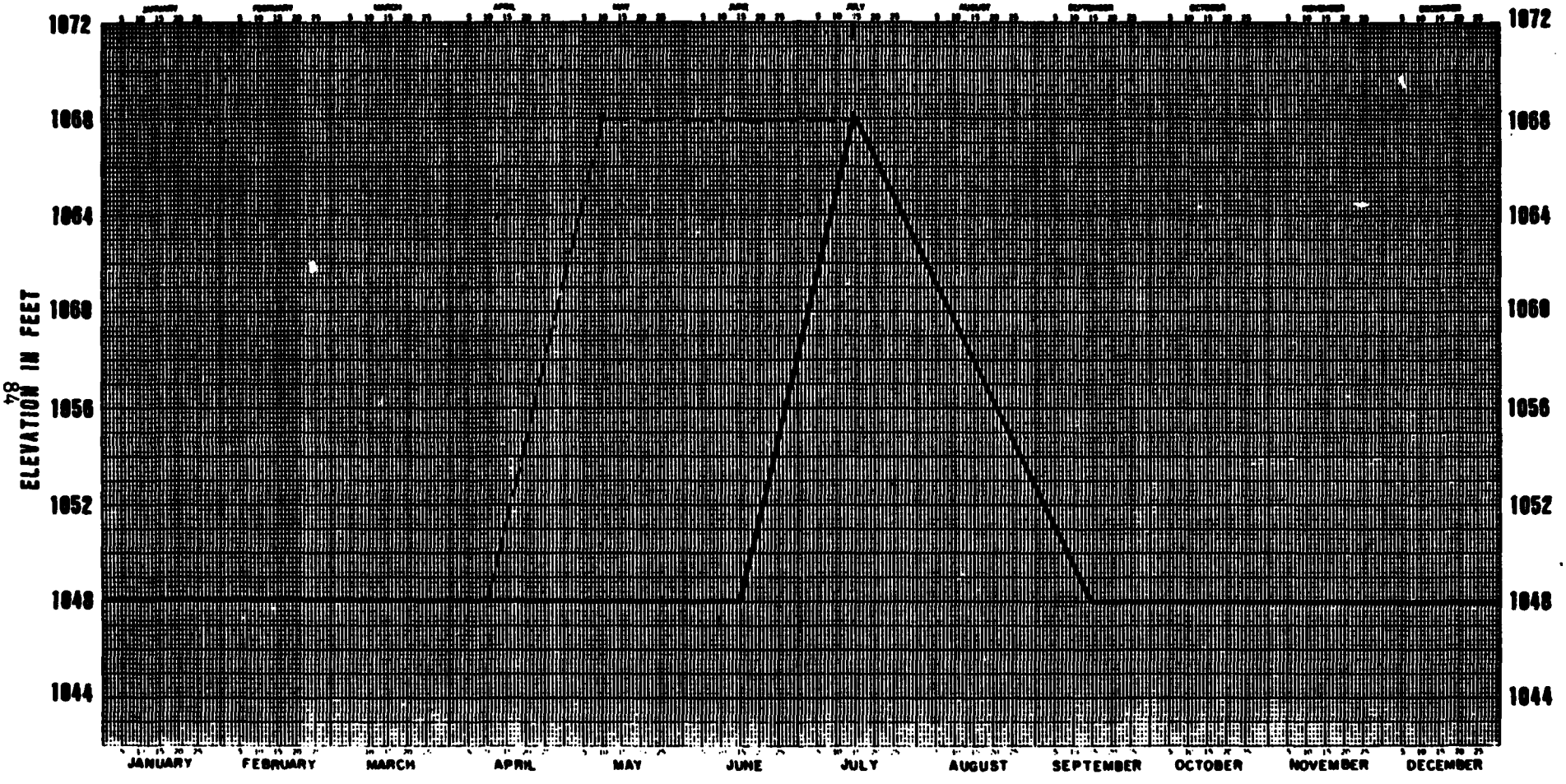




ALTERNATIVE 8

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1068.0 to 1064.0	Winter drawdown	Begin the winter flood control drawdown as late as possible to reach the required drawdown elevation 1048.0 by April 1. Urban flood conditions at Wahpeton-Breckenridge typically occur about April 10. Drawdown may not be needed every year. The target drawdown schedule is to lower the pool to elevation 1048.0 by April 1. Depending on the predictive capability, raise the target elevation to reflect the prevailing hydrologic conditions, but no lower than elevation 1048.0. Reserve adequate storage, if possible, for the spring drawdown for the purpose of agricultural flood control.
Flood Control			
Spring breakup to about June 15	1064.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached, then use the surcharging rules. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1068.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1068.0 and the surcharge is disposed of.
		Spring drawndown	If a spring drawdown is needed, draw down the pool as needed. Complete it, if possible, by May 15. Most agricultural flooding occurs between May 15 and June 10. If the drawdown is not needed, return to the normal full pool elevation 1068.0 as soon as possible, while following the rules to dispose of the surcharge.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1068.0 and the surcharge is disposed of.
Routine Operation			
About June 15 to September 20	1048.0 to 1068.0	Filling reservoir	Return to normal full pool of 1068.0 as soon as possible, and maintain it by discharging the inflow. Minimum normal low flow is 80 cfs, and the channel capacity is 1,200 cfs.
Drought			
Low water period in Red River	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.



ALTERNATIVE 9

FIGURE 28

ALTERNATIVE 9

Regulation Schedule - Orwell Dam and Reservoir

Regulation Schedule	Stage	Condition	Operations
Routine Operation			
Freezeup to spring breakup	1048.0	Winter	Each year from September 20 until spring breakup, attempt to maintain elevation 1048. Outflow should equal inflow. Maximum discharge shall not exceed 1,200 cfs channel capacity, except that downstream channels may reduce channel capacity until breakup.
Flood Control			
Spring breakup to about June 15	1064.0 to 1070.0	Flood protection	When spring breakup begins, store inflow as necessary to assist in preventing or reducing flood damages at Wahpeton-Breckenridge. Storing of inflow shall continue if necessary until elevation 1070.0 is reached. Channel capacity is 1,200 cfs.
	1070.0 to 1075.0	Surcharging pool	If conditions at Wahpeton-Breckenridge still require the storing of inflow, surcharge pool by discharging 90 percent of inflow but not less than 1,200 cfs and store balance. Surcharging shall continue if necessary until pool reaches elevation 1075.0.
	1075.0 to 1070.0	Disposing of surcharge	If the pool reaches elevation 1075.0, discharge inflow but not less than 1,200 cfs. Once surcharging has begun, do not decrease tainter gate opening until pool has dropped to elevation 1070.0 and the surcharge is disposed of.
		Spring drawdown	When the pool is below elevation 1070.0 and the stage at Wahpeton-Breckenridge permits, the spring drawdown shall begin, if needed, by discharging up to 1,200 cfs until the pool is lowered to elevation 1048.0, if possible. Maintain elevation 1048.0 by discharging inflow until it becomes necessary to begin storing inflow for flood prevention or to begin filling the pool to 1068.0 by July 15.
		Fall and summer floods	Up to elevation 1070.0, release the channel capacity of 1,200 cfs. Between elevations 1070.0 and 1075.0, surcharge the pool by releasing 90 percent of the inflow, but not less than 1,200 cfs, until the inflow subsides. Once surcharging has begun, do not decrease the tainter gate opening until the pool has dropped to elevation 1070.0 and the surcharge is disposed of. Return to rule curve in a reasonable amount of time, if possible.
Routine Operation			
About June 15 to September 20	1048.0 to 1068.0 to 1048.0	Filling reservoir and instream flow supplement	Between July 15 and September 20, the pool shall be lowered to 1048.0 to supplement instream flow. Minimum discharge is 80 cfs year round, and the channel capacity is 1,200 cfs.
Drought			
Low water period in Red River	1068.0 to 1048.0	Inflow less than 80 cfs	When reservoir inflow from the Ottertail River is less than 80 cfs: 1. First 30 days: Maintain release of 80 cfs unless the pool elevation drops to 1060.0, then release inflow and contact the MDNR, Division of Waters. 2. 31 to 60 days: If inflow is between 70 cfs and 80 cfs, continue releasing 80 cfs; unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. If inflow is less than 70 cfs, then release the greater of: (a) inflow plus 10 cfs, or (b) 50 cfs, unless the pool drops to elevation 1060.0, then release inflow and contact MDNR. 3. 60+ days: If inflow remains less than 80 cfs for longer than 60 days, contact the MDNR for a coordination meeting and discharge as in item 2 above. Note that discharge changes should be done gradually over several days to a week during critical low-flow periods.

Subimpoundments For Wildlife

During public involvement activities, the MDNR suggested that certain branches or arms of the reservoir be considered for subimpoundments. Members of the Corps study team accompanied the MDNR area wildlife manager in a field inspection of the areas by boat and truck.

The study team members inspected a number of small bay areas that could be isolated from the main reservoir by low berms. A gated outlet for each subimpoundment would allow management of water levels for waterfowl production. The subimpoundments are an advantage because pool elevations of the main reservoir are often counterproductive for waterfowl management.

One subimpoundment is recommended for construction by the St. Paul District. This recommended subimpoundment would provide management control of about 220 acres at elevation 1070 msl located south of the CSAH 2 crossing of the reservoir's south arm. The area can be identified on Figure 1 and Plate 7. The drainage of this area flows to the north and is controlled by two culverts under CSAH 2. Upon inspection, the larger, 7-foot culvert appears to require replacement within the next 5 to 10 years. The over 30-year-old corrugated metal pipe (CMP) was placed under the CSAH 2 embankment when the roadway was raised as part of the Orwell project. The top of the culvert appears to be sagging about a foot in the middle of the roadway. The culvert was found to be free of siltation and debris. The smaller 3-foot culvert was found to be about half plugged with silt, but intact.

The recommended subimpoundment area receives runoff from a 25-square mile drainage area. In most years, that area would provide sufficient runoff to fill the subimpoundment to a satisfactory level, without requiring inflow from the main reservoir. This would help prevent invasion of rough fish from the main reservoir and make the filling of the subimpoundment independent of filling the main reservoir.

A stoplog structure is also needed inside the pipe to minimize the introduction of carp into the subimpoundment and control the level of the subimpoundment. Both aluminum and wooden stoplogs were considered. Concrete pipe was also considered for the replacement culvert. Plate 8 shows a conceptual diagram of the culvert and control features.

The other potential subimpoundment sites would require construction of earth berms with control gates. Several of these sites were considered but are not being recommended for Federal implementation at this time.

Non-Federal Development of Subimpoundments

Non-Federal wildlife groups might be interested in developing some or all of these subimpoundment sites. The MDNR has indicated a desire to coordinate non-Federal proposals with the St. Paul District. The sites are appropriate for non-Federal development and would not significantly reduce the flood control benefit of the project if the tops of the control berms are maintained below elevation 1074 msl. Development of subimpoundment sites would in fact increase the recreation benefit of the project by increasing opportunities for viewing wildlife and for hunting. Development of these subimpoundment sites by the MDNR or others is encouraged by the St. Paul District. The MDNR should begin coordination of any subimpoundment conceptual designs with the St. Paul District prior to development of detailed designs.

Aquatic Habitat

The aquatic habitat in the reservoir is limited because of the lack of aquatic vegetation. The vegetation cannot develop because of the large pool fluctuations. The drawdown zone bottom is exposed for long periods, and much of the bottom is frozen during the winter. The depth of sunlight penetration is only about 6 feet, and the pool is nearly always dropping or raising for flood control or pollution abatement purposes. The alternatives considered provide an organized grouping of

pool fluctuations to allow a sensitivity evaluation of pool fluctuation impact on aquatic habitat in the reservoir.

The most important aquatic habitat affected by the project is in the tailwater of the dam. The flow requirements of this aquatic habitat are reflected by the instream flow requirements described previously.

Hydropower

An evaluation of Federal hydropower developement was not considered in detail for Orwell Reservoir because of recent changes in Federal water resource policy. Thus, hydropower considerations did not enter into plan formulation activities. Non-Federal developers should assume that the reservoir operation plan recommended for testing in this report will not be changed significantly to maximize hydropower benefits. A more appropriate assumption is that whatever flows that would be available from the proposed operation plan could be used for hydropower generation. Thus, peaking operation and possibly other hydropower operation patterns are not compatible with the authorized and other recognized purposes at Orwell. A potential non-Federal developer should coordinate its plan formulation activities closely with the St. Paul District and other agencies involved in the FERC licensing procedures.

Cultural Resources

The most important plan formulation consideration for cultural resources is to eliminate shoreline erosion. See the Plan Formulation section of this report concerning the formulation of project features to control shoreline erosion.

Recreation Resources

The Orwell Reservoir lies on the edge of a major vacation area that provides year-round fishing and hunting opportunities. To support these recreational pursuits, additional facilities are needed. These

facilities include campgrounds, sightseeing opportunities, river/lake accesses, interpretive facilities, swimming areas, and hiking, bicycling, and canoeing trails. A canoe route should be considered from an access point near Fergus Falls or along the Pelican River to the Orwell Reservoir. The MDNR is still interested in developing a canoe route on the Ottertail River. They may also be interested in coordinating other facilities to accommodate canoeists, such as rest stops, portage routes, primitive campsites, and toilet facilities. The recommended operating plan would contribute to the summer flows to improve canoeing conditions in most years.

To provide water-related recreational opportunities on Orwell Lake, shore-edge erosion must be controlled and maintained, and lake levels must remain somewhat stable. Both of these needs are addressed in the recommendations of this report. By controlling erosion and stabilizing pool levels, fishing habitat would be greatly improved and could then contribute to sport fishing recreation on the reservoir.

The purpose of the Orwell Wildlife Management Area is to provide waterfowl and wildlife habitat, which in turn provides recreational hunting and viewing opportunities. The demand for upland and waterfowl hunting in Minnesota's Region 4 and North Dakota's Region 5 are extremely high. Low-density recreational activities that are appropriate at the Orwell site would include sightseeing, interpretive facilities, nature study, birdwatching, boating (canoes, sailboats, rowboats, and motorboats under 10 horsepower), trails (hiking, bicycling, and cross-country skiing), fishing, hunting, camping, and minor support facilities. Motorboats (over 10 horsepower) would not be appropriate because the noise and wake action would damage the habitat, continue shoreline erosion, cause congestion, and eliminate the quiet atmosphere.

Impacts of recreation in the wildlife management area can be minimized by coordinating the activities of people to the wildlife and fish space needs, seasonal calendar, and activity locations. Impacts can also be

minimized by rotating recreational activities, closing areas, renting equipment, establishing further water surface zoning and enforcement, designing the recreational area to provide hard surfacing where needed, locating recreational activities near roads and boundary edges where the impact is much less, channeling people away from sensitive areas, and dispersing recreational activities.

Because of the scarcity of recreational resources in Region 5 of North Dakota more recreationalists may be attracted to Minnesota for hunting, fishing, cross-country skiing, swimming, and boating opportunities.

A more positive and visually exciting route to the Orwell Dam can be promoted and marked on Highway 15, which leads from Fergus Falls over I-94 to Highway 114. This route gives the visitor occasional glimpses of the water landscape, increasing the excitement before reaching the damsite.

Major transportation corridors, such as the North Country Trail, the Ottertail River, and Interstate I-94 should be considered when planning future recreation facilities. The Orwell Reservoir could become an important recreational mode, providing needed campsite/rest areas, water access points, trails, interpretive facilities, and sightseeing opportunities. These recreational opportunities can be promoted through the Otter Tail Museum by providing brochures, and/or a display, and/or adding to the existing car-tape tour for sightseeing.

Potential Recreation Project Features:

1. Accommodate bank fishermen by providing a safe, easily accessed fishing platform or dock.

2. Accommodate hunters and other recreationalists by providing camping and other support facilities that are compatible with the site.

3. Provide sightseeing opportunities for maximum viewing from the highway below the dam and in other areas of the reservoir.

4. Enhance the recreational experience by providing the following additional or improved recreational facilities:

   a. Provide a warm welcome for visitors.
   b. Shade existing picnic area.
   c. Provide buffers to parking and restroom areas.
   d. Minimize the linear picnic area.
   e. Correctly place or eliminate signage.
   f. Maximize views.
   g. Address pedestrian and vehicular circulation.
   h. Eliminate the split site perception.

The objective of the Corps recreation program is to fully consider the recreation potential at Corps Civil Works projects and to capitalize on that potential for the benefit and enjoyment of the public. Inherent in this objective is the goal to provide an economical and quality program that will provide the public with a diverse recreational experience, along with the wise use of natural resources. These objectives require sound planning, development, and management of all available resources including facility development and operation costs. The Orwell Reservoir is considered an important site for providing future recreation for the public. It is recommended that the existing master plan be considered for updating to determine the feasibility of additional recreational facilities and to locate a cost-sharing sponsor.

EVALUATION

Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, dated March 10, 1983, is used for the evaluation of Federal water resource projects, such as the Orwell project. The principles and guidelines specify how to assess the magnitude of effects a project has on its purposes and significant

resources. Standard engineering, environmental, and economic principles are used in the procedures to determine a relative value for the project's contributions to each purpose.

The following paragraphs summarize the evaluation activities that were accomplished during this study. The evaluation activities determined the average annual benefits of the existing operating plan and alternative operating plans that were considered.

SUMMARY OF EVALUATION ACTIVITIES

Downstream Channel Capacity (Zero-Damage Discharge)

The February 1985 Problem Appraisal Report indicated that a review of the zero-damage discharge assumption was needed. The existing reservoir regulation manual uses the figure of 900 cfs as the assumed bank-full capacity. The 900 cfs figure has been assumed to be the capacity of the downstream channel because a downstream Corps channelization project was constructed in 1955 to a design discharge of 900 cfs, with some freeboard. The channelization project was found to be in very good condition during the last inspection. The condition of the Ottertail River channel upstream of river mile 21.1 and downstream of the dam was checked by the dam tender, using a snowmobile to facilitate access. There are a few downed trees or other similar snags in a few reaches of the river, but the channel is generally in good condition.

During the spring and early summer of 1985, unusual amounts of rainfall provided an opportunity to review the channel capacity assumption. The rainfall provided significant inflows to the reservoir as well as more than normal inflows to the river channel between the reservoir and Breckenridge.

Discharge from the reservoir ranged from 1,000 cfs initially to 1,200 cfs through the end of July 1985. The discharges continue to be high into October 1985. During that time, the downstream reaches of the

Ottertail River were inspected by a reconnaissance hydraulic engineer who found that a discharge of 1,000 cfs remains within banks. When the discharge reached 1,200 cfs, the dam tender interviewed downstream farmers located along the channel. They indicated that the flows were not interfering with their agricultural operations. The Corps Water Control Center, the MDNR area hydrologist, and the Breckenridge, Minnesota, City Engineer indicated that they had not received any complaints about the 1,200 cfs discharge.

The present regulation manual (paragraph 30 on page 21) for the reservoir indicates that during the spring and summer of 1963 flows exceeding 1,100 cfs were passed without any appreciable flooding or damage. Plate 12 of the manual contains a curve for elevation-area flooded. The curve indicates that, for a discharge of up to 1,200 cfs, no agricultural land would be flooded. Discharges in excess of 1,200 cfs begin to accrue flood damages.

The value assumed for the zero-damage discharge has a significant effect on the amount of flood control storage required for the smaller floods. Figure 18 indicates the variation of approximate storage required for three historic flood events using channel capacities of 900 and 1,200 cfs. The three hydrographs that were used for these comparisons are typical historic flood events with peaks that match the related frequencies from the inflow frequency curve on Plate 6. The frequency curve on Plate 6 was developed by reverse routing the recorded information from USGS gage located just downstream of the reservoir. The Orwell Reservoir has a storage capacity of approximately 19,400 acre-feet available below pool elevation 1075 (maximum surcharge elevation) and above elevation 1040 (minimum drawdown elevation).

Flood Control Storage Sensitivity to Channel Capacity

	Storage Required in Acre-Feet (Channel Capacity)	
Flood Event	1,200 cfs	900 cfs
25-year	7,000	31,500
10-year	2,100	14,500
2-year	500	12,800

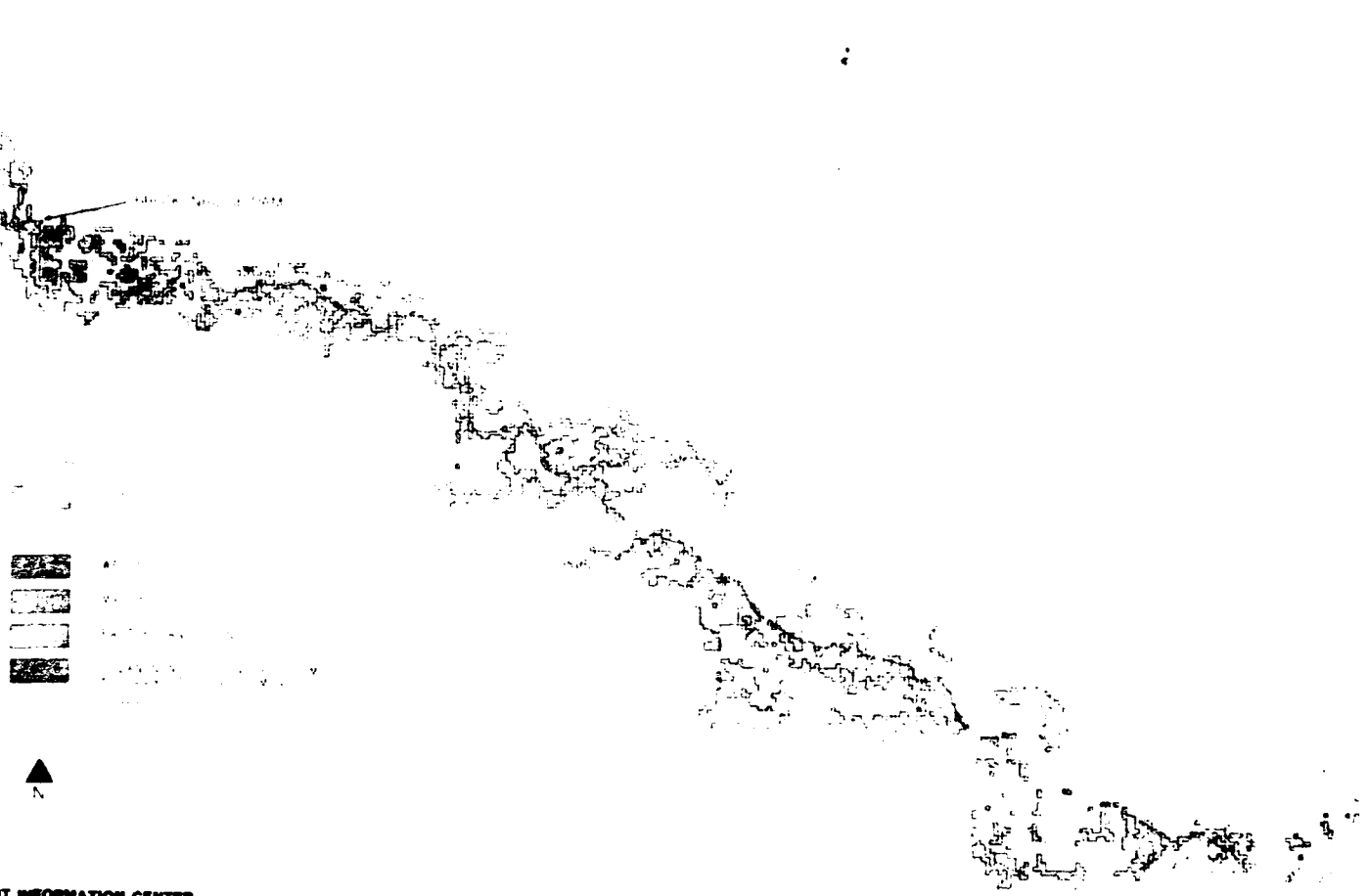
For the purposes of testing the recommended reservoir operation plan, the assumed channel capacity figure should be increased to 1,200 cfs, based on these 1985 evaluations. The 1,200 cfs channel capacity figure should be reviewed during the recommended test period when conditions permit. However, it would be improper to increase the releases beyond 1,200 cfs to determine when flood damage is induced for the purpose of identifying the exact figure, unless actual flooding conditions permit it.

Flood Control

One of the authorized purposes of Orwell Reservoir is flood control. Average annual flood control benefits were computed for the existing reservoir operation plan and for alternative operation schemes. The benefits are shown on the alternative comparison table on page 120.

Flood control benefits include the reduction of agricultural damages between river miles 9.7 and 24.8. The benefits for the agricultural reaches were determined using land use data from the State of Minnesota's Land Management Information Center (LMIC). The information is stored in a computer data base and can be output in tabular and graphic form. The land use information was combined with discharge-area information to compute benefits for the existing and alternative reservoir operation plans. The graphic output from the LMIC data base is shown on the following photographs of the computer plots. The graphic land use information was also used for the recreation evaluation.

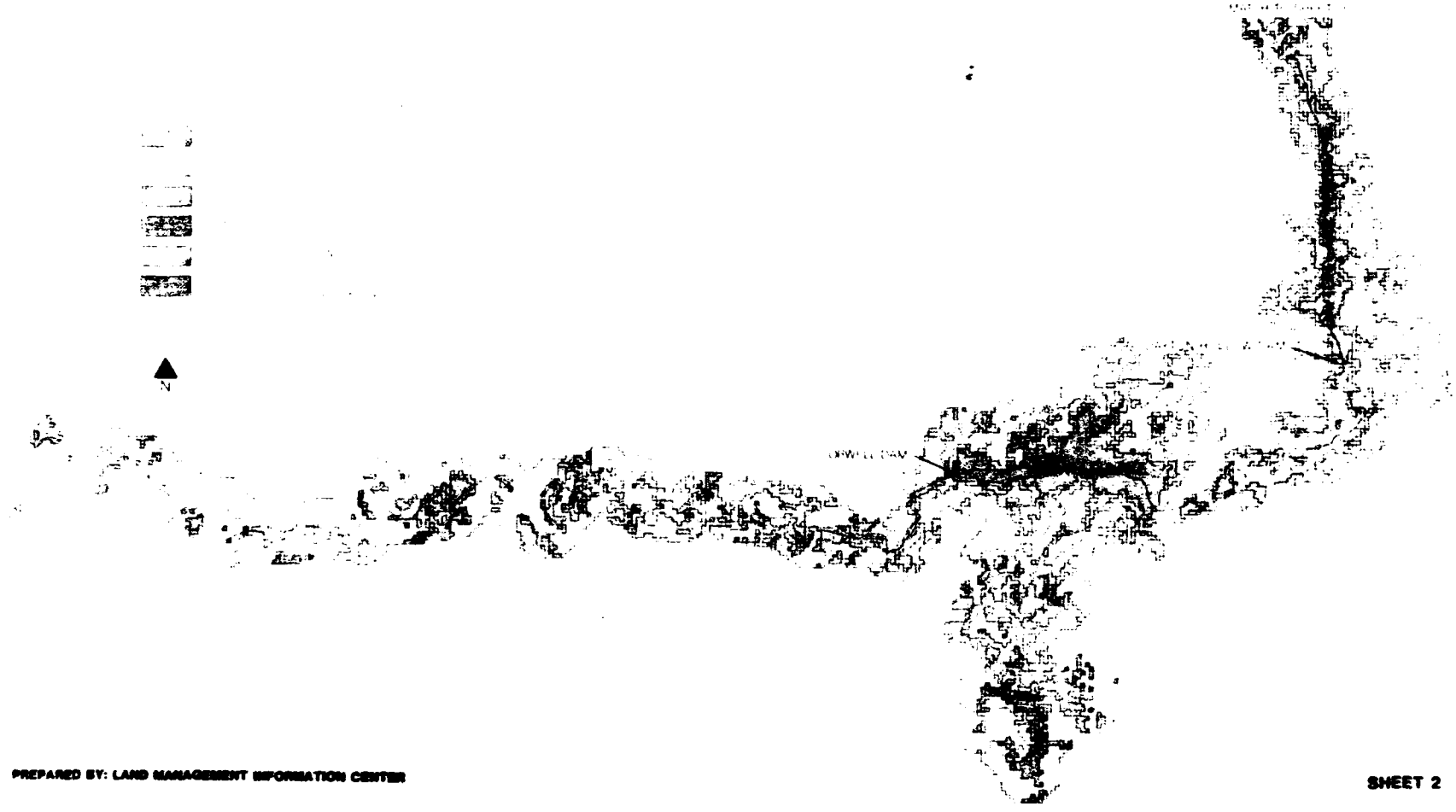
OTTERTAIL RIVER FLOODPLAIN
WEST SECTION



PREPARED BY: LAND MANAGEMENT INFORMATION CENTER

SHEET 1

OTTERTAIL RIVER FLOODPLAIN
CENTRAL SECTION



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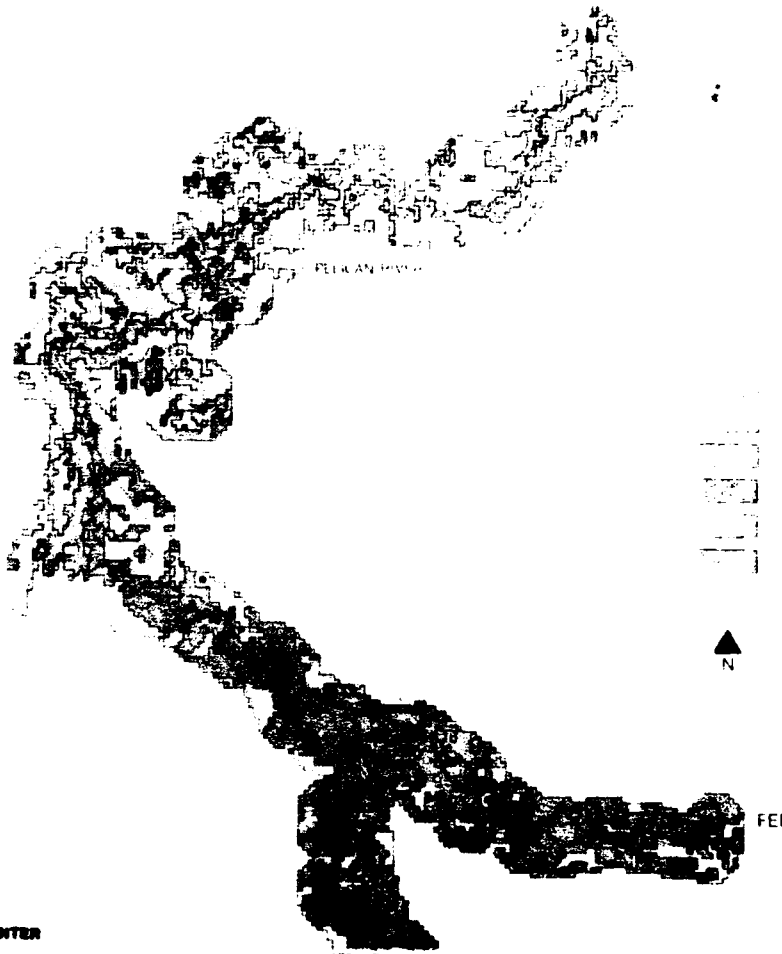
SHEET 2

OTTERTAIL RIVER FLOODPLAIN
EAST SECTION



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SHEET 3

The Orwell project also provides urban flood damage reduction benefits for Wahpeton, North Dakota, and Breckenridge, Minnesota. Inventories of flood-prone structures in the 100-year floodplain were obtained for Wahpeton and Breckenridge. Inventory information about the structures' values and elevations was evaluated using the Corps Expected Annual Damages (EAD) computer program. The April flood event profiles used in the EAD computer model were developed from an existing HEC-2 computer model developed in 1971 by the USGS. The April flood profiles are considered to be preliminary data and could be subject to major revisions at a later date. However, the profiles are adequate for comparing the relative flood control benefits of the existing Orwell Reservoir operation with alternative schemes.

Flood profile information for alternative operation plans and the pre-reservoir (no reservoir storage) condition was developed by routing historic hydrographs. The inflow discharge-frequency curve on Plate 6 was developed by reverse routing peak discharge events from the downstream USGS gage back through the reservoir operation recorded for that event. The peak inflow discharges for the 2-, 10-, 25-, 50-, and 100-year flood events were determined using the computed inflow frequency curve. Typical historic flood hydrographs were selected that matched the peak discharges of interest, except for the 100-year flood. The 100-year flood event was developed from the 50-year flood because no floods of the 100-year magnitude have occurred at the Orwell project. Those hydrographs were then routed through the alternative reservoir operation plans and the no reservoir (no storage) condition. The resulting discharge hydrographs were then routed downstream to the damage reaches using the average lag routing method.

Probable Maximum Flood (PMF)

The PMF hydrograph for Orwell Reservoir was recently developed for the dam safety evaluation. The peak discharge of that hydrograph is roughly 24,000 cfs. The volume of the PMF is much greater than the capacity of the Orwell Reservoir. The volume of the PMF is so great, in fact, that

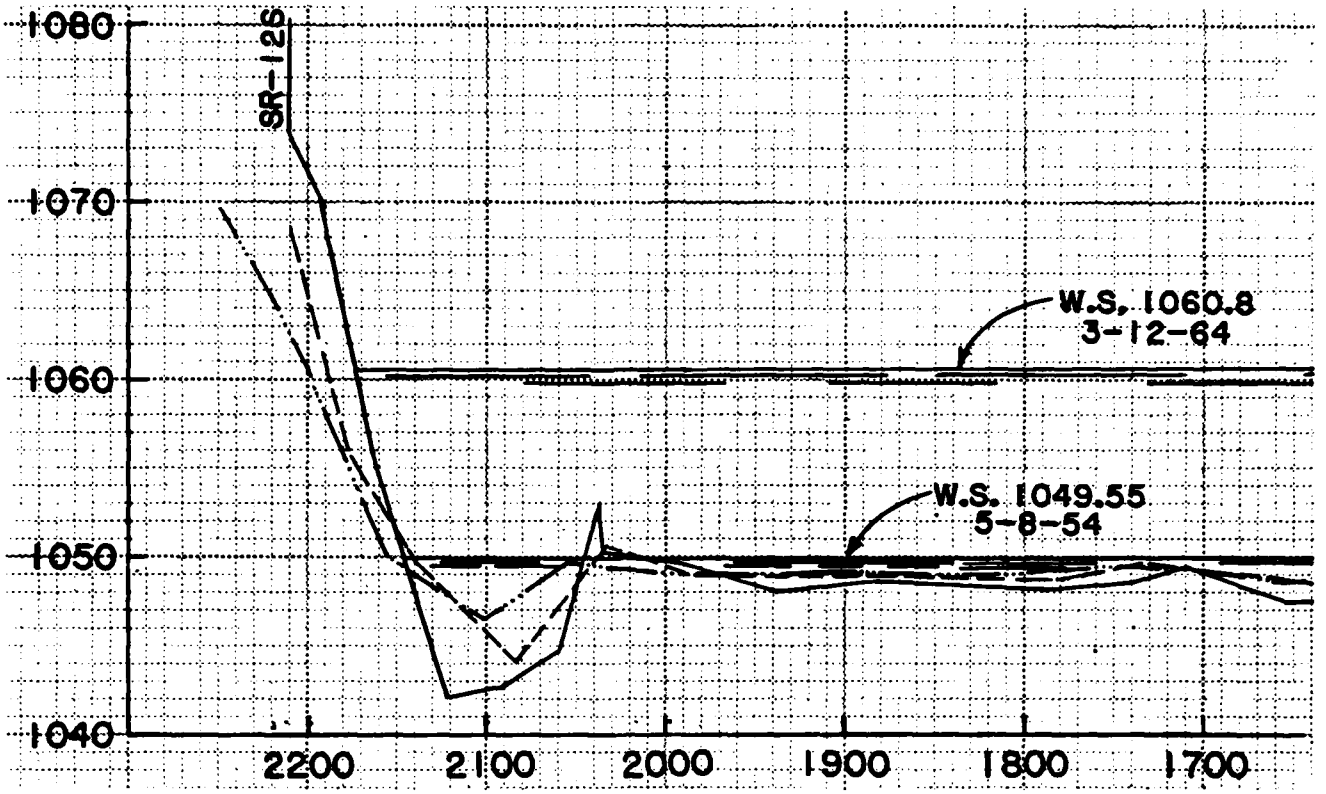
the existing operation plan for pool elevations under 1,070 has no effect on either the downstream discharges or the maximum pool elevation reached during the PMF. The other alternative operation plans evaluated also have insignificant effects on the PMF downstream disscharges and the ultimate pool elevation during the PMF.

Sediment Survey

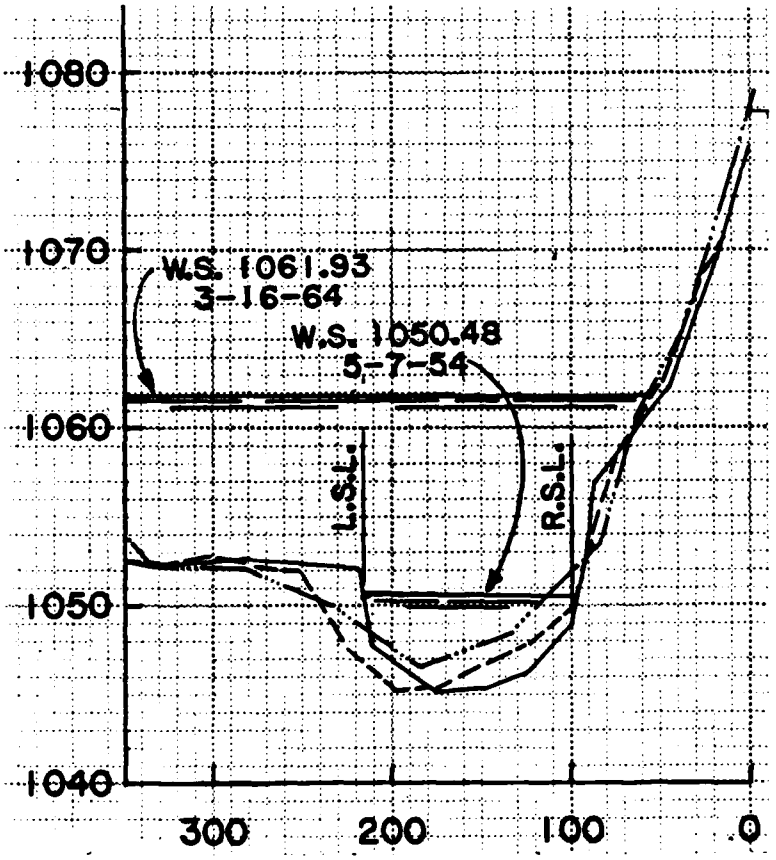
The 24 sediment ranges, established in 1955, were resurveyed in 1964 and during this study. The recent field measurements were taken in January and February of 1985. The 24 established and 18 supplemental ranges were plotted in March 1985. The 18 supplemental ranges were taken for environmental evaluation purposes. The 1985 elevation-capacity curve is currently being developed using the average end area method with only the 24 established ranges. The old and new curve and data points are shown on Plate 4. The sedimentation data and computations will be submitted for approval to the Corps North Central Division (NCD) office in Chicago, Illinois. All calculations and routings done for this study used the old elevation-area and storage volume relationships. The routings and information displayed in the updated reservoir regulation manual should reflect the 1985 data.

The 1985 sedimentation data indicate that some of the shoreline areas continue to erode. Figure 29 shows the shoreline erosion at sedimentation ranges 12 and 13. Range 12 shows the greater amount of erosion that is taking place on the south shores.

Range 13 shows the smaller amount of erosion that is taking place on the north shores. The deeper portions of the reservoir have probably received limited amounts of sediment from erosion occurring on the hillsides surrounding the reservoir. Figure 30 shows typical bottom areas from sedimentation ranges 4 and 6. The right shore line (R.S.L.) is on the north end of the transect. Sedimentation appears to be occurring at a very slow rate. The fine material is suspended in the



RANGE NO. 12



RANGE NO. 13

LEGEND

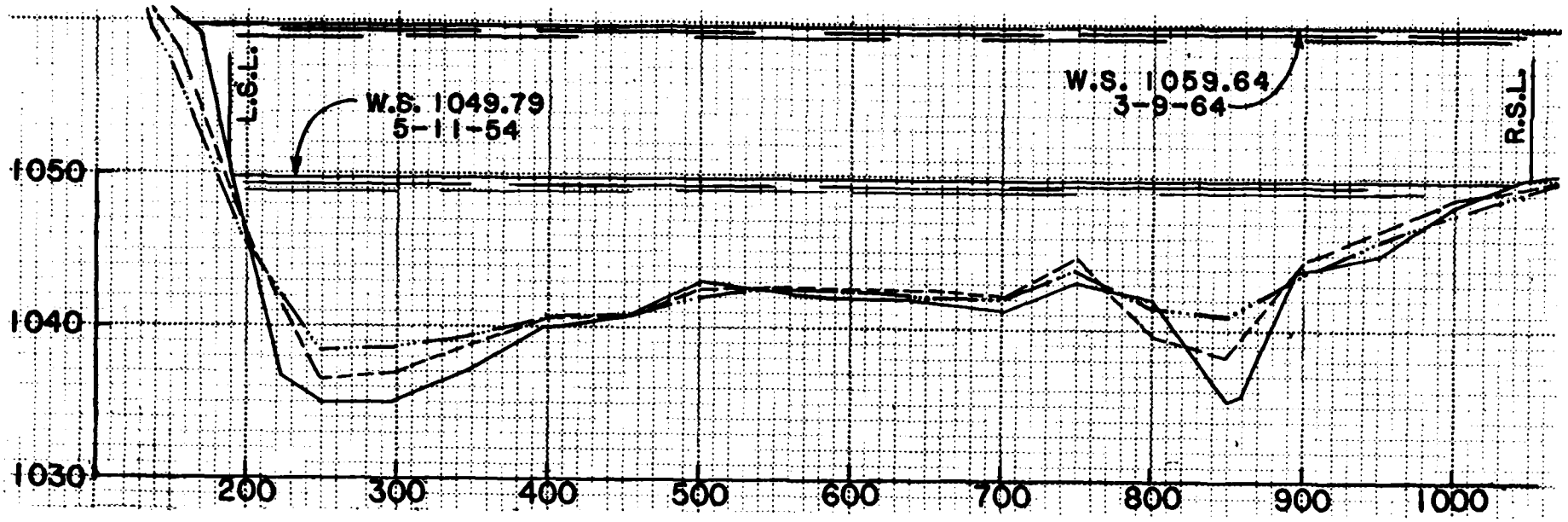
——— CONDITION AS OF 1954

– – – CONDITION AS OF 1964

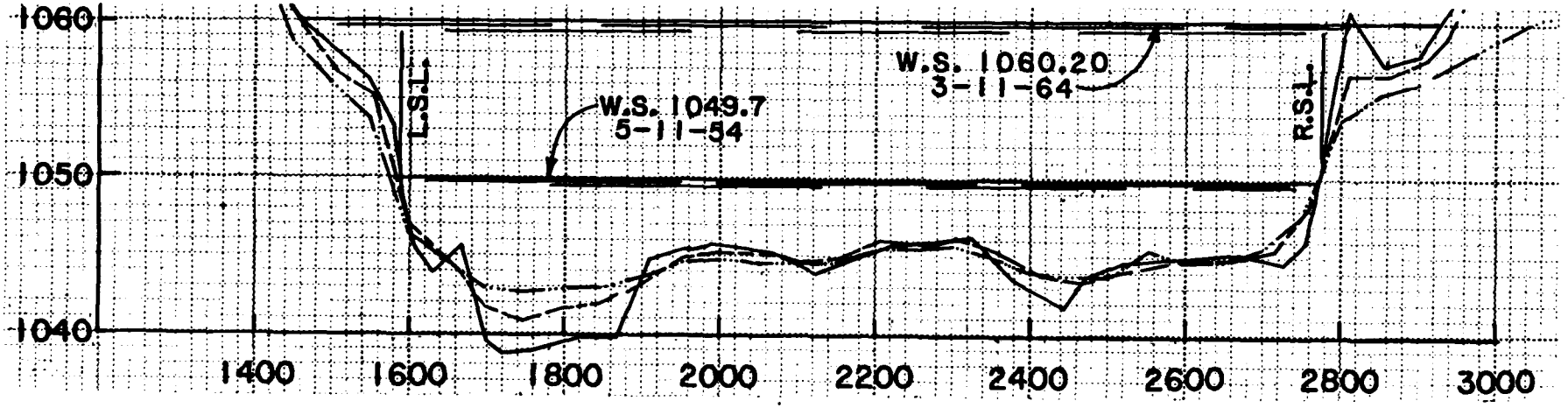
—·—·— CONDITION AS OF 1985

FLOOD CONTROL PROJECT
OTTER TAIL RIVER MINN.
ORWELL RESERVOIR
EXAMPLES OF SHORELINE EROSION

FIGURE 29



RANGE NO. 4



RANGE NO. 6

LEGEND

——— CONDITION AS OF 1954

– – – CONDITION AS OF 1964

—·—·— CONDITION AS OF 1985

FLOOD CONTROL PROJECT
OTTER TAIL RIVER MINN.
ORWELL RESERVOIR
EXAMPLES OF BOTTOM DEPOSITION
FIGURE 30

water column and is carried out of the reservoir. The coarser material forms a "beach" at the base of the cut banks. Inflow of sediment from upstream is likely restricted by the presence of the Dayton Hollow Dam and numerous lakes in the upper portions of the basin. Thus, there has apparently been little net change in reservoir storage capacity since 1955. Sedimentation in Orwell Lake because of shoreline erosion should decrease with the lower normal full pool and establishment of vegetation near the shore as recommended in this report.

The next regular sedimentation survey should be scheduled no sooner than January 2015. The updated reservoir regulation manual will contain the recommended schedule. An emergency survey might be needed prior to the scheduled time if an unusual flood event occurs or the operation or condition of Dayton Hollow Dam changes significantly.

Shoreline Erosion

A considerable amount of shoreline erosion has occured since Orwell Lake was first impounded in 1953. A report by John Reid from the University of North Dakota identified the primary shoreline erosion process to be wave action accompanying high pool levels and, to a lesser extent, freeze-thaw and rainfall. Figure 31 illustrates the relative rates of erosion from each process. Apparently, wave action during storms removes material from the base of the bluff areas, leaving nearly vertical faces at some locations. Figure 32 illustrates how material has been removed from the bank bases by wave action. Freeze-thaw and rainfall replenish the vertical base areas with soil from the higher areas, and the cycle continues. Thus, a nearly vertical erosion face tends to migrate through the banks and hillsides. Past attempts to quantify bank recession resulted in very high rates of 0.8 meter per year (Reid, 1980) at station 3. The average rate for all the stations is 0.36 meter per year. The higher and steeper banks are subject to faster and more destructive erosion.

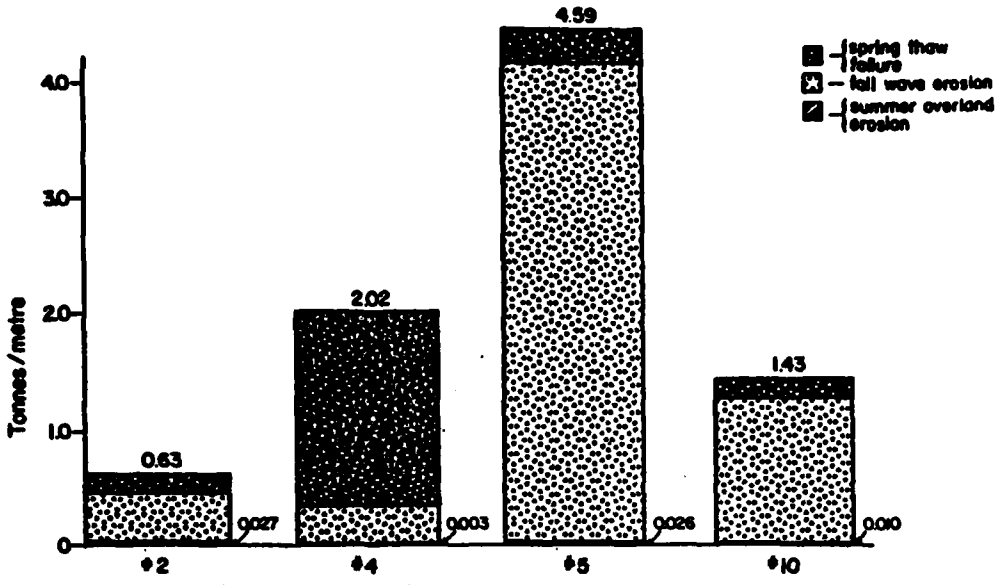


FIGURE 31 - Total bank erosion at four erosion stations, 1981-82 (Reid, 1980)

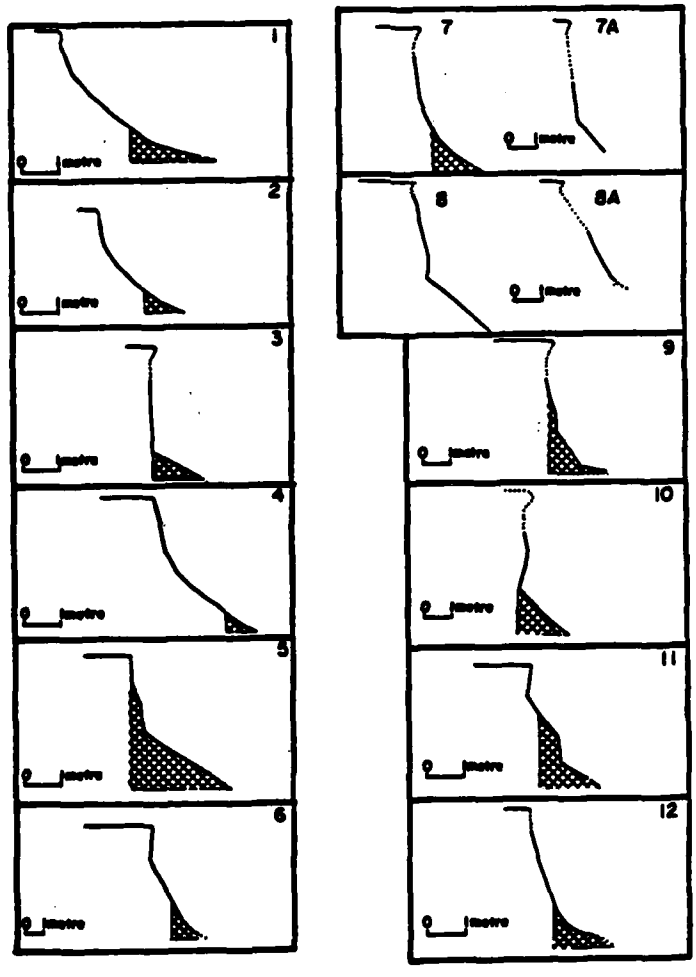


FIGURE 32 - Profiles of Orwell Lake banks at Overland Erosion Station sites before and after wave modification in October 1981. The pattern area was removed by lake erosion (Reid, 1980).

The report by Reid was done for the Corps of Engineers Cold Regions Research Lab (CRREL) under contract number DACW89-81-002. The most important recommendation contained in the contract report is to reduce the amount of time that the pool is held above elevation 1067.9 to reduce shoreline erosion. This change is expected to encourage establishment of a stable protective slope at the base of the bluff areas rather than an erosion-prone vertical face. The recommendation also stated that the exposed lower slopes be vegetated or allowed to vegetate naturally to protect them from further erosion. It is doubtful that the base slope would stabilize without vegetative cover.

Stable base and upper slopes would require a number of years to establish. The bluff crest would continue to recede until the entire slope, from base to crest, arrives at a stable angle. That angle is estimated by Reid to be approximately 30 to 35 degrees or roughly 1 vertical to 1.5 horizontal, or flatter.

The contract report also states that the erosion processes other than wave action will continue to work on Orwell's hillsides. Those processes are expected to continue unaffected by the proposed lower normal full pool. For example, freeze-thaw failure will continue to occur, with 75 percent of that method of erosion affecting northerly-facing slopes. Massive rotational slumping can be expected to occur following drought periods, especially at the east end of the lake where the culprit lacustrine soil unit is stratigraphically and topographically favorable for such failure. Additionally, rainfall will cause a moderate amount of erosion to occur at an evenly distributed rate around the reservoir. If the vegetative cover is established as recommended by Reid, it would minimize the rainfall-caused erosion. Freeze-thaw and rotational slumping are not reasonably preventable, but fortunately cause only a small portion of the total erosion.

Project Boundary

Shoreline erosion has already progressed to outside project boundaries in one area (see Figure 6 on page 29). The St. Paul District has proposed to acquire about 30 acres of land that encompasses the problem site. Planting of shrub willow and green ash on the base slopes of eroding banks as recommended should reduce further wave erosion during pool surcharge periods and eventually should afford rainfall erosion protection to the cut banks. Vegetation established on the base slopes should speed revegetation of the cut banks, and thereby improve the aesthetic character of the reservoir.

Unchecked shoreline erosion at other Orwell Lake sites (see Figure 5 on page 28) could progress at some future time, probably more than 50 years in the future, to outside project boundaries. The proposed reservoir operation plan may reduce the rate at which the erosion faces recede toward the project boundaries. However, erosion should be expected to continue to occur at many of the presently eroding banks, but possibly at a slower rate, until the erosion faces attain a more gradual and stable slope. That does not mean that the proposed reservoir operation plan would contain all of the shoreline erosion within project boundaries.

Additional acquisition will not likely be needed for a long time, because none of the other active erosion faces are close to project boundaries. The factors involved with the shoreline erosion problem are not sufficiently predictable to warrant acquisition of additional project lands at this time, other than the 30-acre site already being proposed for acquisition. In fact, it is uncertain whether additional acquisition would even be needed.

Pollution Abatement (Waste Assimilation) and Water Supply

The downstream interests contacted during this study indicated that summer low-flow supplemental releases are needed to satisfy aesthetic and recreation-related uses of the river as well as improved water quality for water supply demands during the annual low flow period. Of course, during an extended drought the water supply interests would need to depend heavily on ground water, as in 1976.

An extensive study would be needed to accurately assign a dollar value to pollution abatement and water supply benefits related to the expressed needs. The study would need to identify the monetary benefits for supplementing summer low flows and would likely consider the following factors:

1. Changed chemical treatment and energy costs related to ground-water pumping (the most likely alternative).

2. Reduced chemical costs for softening, reducing dissolved solids concentration, and reducing alkalinity of river water released from Lake Traverse. For example, the Moorhead Water Department indicated that they had overspent their chemical treatment budget by $80,000 in a 2-month period when Lake Traverse releases were much greater than normal.

3. Possible reduced costs at waste-water treatment facilities.

4. Increased future water demands may drive up any of the average annual values of the above three factors.

The comprehensive study summarized in the previous paragraphs is outside the scope of the Orwell ROPE effort. Thus, a number of assumptions had to be made to simplify the evaluation and comparison of the pollution abatement benefits associated with water supply. The assumptions are summarized as follows:

1. The Orwell Reservoir volume is very small compared to the downstream water supply need.

2. The summer pollution abatement releases are needed most during the period from July 15 to September 20 in an average year.

3. Combining the above assumptions: the greatest benefit is derived by providing the greatest average discharge during the period from July 15 to September 20. This assumption is used as an indicator of contributions to this project objective.

Assumption 3 was used as the criterion for comparison of pollution abatement contributions to water supply needs by the alternative operation rule curves that were considered. However, this criterion was not entirely satisfactory for evaluating tradeoffs between pollution abatement and other project purposes. In other words, a unit of discharge for pollution abatement purposes is not necesarily of equal value as a unit of discharge or storage for another project purpose.

Consideration of the pollution abatement contributions to aesthetic and recreation related uses along the Red River follows essentially the same reasoning as for water supply purposes. Breckenridge, Wahpeton, and Moorhead indicated that releases are needed during summer low-flow periods to flush algae and freshen the river for aesthetic purposes and to enhance recreation activities in and near the Red River. Using the same three assumptions above, it was determined that the same criteria should be used to compare alternative operation rule curves. To summarize, the greatest pollution abatement contributions to aesthetic and recreation related uses would be provided by the greatest average discharge during the period from July 15 to September 20.

Hydropower

A feasibility evaluation was not accomplished for Federal hydropower development at Orwell Dam because of recent changes in Federal water resource policy. Any potential non-Federal developer will need to evaluate the feasibility of its own hydropower proposals, subject to review by public and agencies during the FERC licensing procedures. See the Hydropower discussion in the Problems, Needs, and Opportunities section of this report for a more detailed discussion of why a Federal feasibility evaluation was not done.

Cultural Resources

An additional field survey is being undertaken for areas not covered in the previous survey. Identified cultural resource sites will be evaluated for their eligibility for the National Register of Historic Places. Project features to reduce shoreline erosion were evaluated to reduce the loss of significant identified cultural resource sites. Contributions to cultural resources are measured in terms of contributions to shoreline protection.

Subimpoundment

Preliminary designs and cost estimates were prepared for replacing the failing metal culvert under CSAH 2 where it crosses the south arm of the reservoir.

	Reinforced Concrete Pipe (RCP)	Corrugated Metal Pipe (CMP)
Pipe	$35,000	$15,000
Aluminum stoplogs	1,200	1,200
Overhead and profit (20-percent)	7,000	3,000
Total	43,200	19,200

The 20-percent overhead and profit amount can be ignored if Corps hired labor crews are used. Aluminum stoplogs are recommended to reduce the

weight for each log from 60 pounds to 23 pounds. The aluminum logs should also last longer, would not swell, and would be easier to move in freezing conditions.

The 7-foot corrugated metal pipe (CMP) is recommended for replacement at the same invert elevations as the existing 6-foot CMP. The size of the culvert was increased to 7 feet to replace the lost capacity of the partially blocked 3-foot culvert at this same roadway embankment. The operation and maintenance are discussed beginning on page 126.

Other subimpoundment sites are available in the reservoir but are not recommended for Federal implementation. These sites are discussed further on page 86.

Low-Flow Control Valves

Cost estimates were prepared for the replacement of the two existing 24-inch double disk gate valves. Two alternatives using knife valves, with 2-foot and 4-foot valves, were considered.

	One 4-foot Gate Valve	Two 2-foot Gate Valves
Valves	-	$60,000
Engineering and design	-	6,000
Supervision and administration	-	4,500
Total	$80,000 to $100,000	$70,500

The 4-foot version was considered because, under low-pool conditions, the 2-foot version cannot pass the target low-flow discharge. The cost estimate for the 4-foot conduit is for a design that roughly follows the location of the existing 2-foot conduit. The effect of removing sufficient concrete from the abutment for the 4-foot conduit is unknown. However, the $10,000 to $30,000 additional cost is probably not justified. A 4-foot conduit through the dam embankment would cost about $200,000. When the pool elevation becomes so low as to severely limit

the low-flow discharge, it is not desirable to release the entire target low-flow discharge. It is recommended that the two 24-inch gate valves be installed at a total cost of about $70,000. When the engineering is done for these valves, butterfly and needle valves will be considered. It may also be possible to install a knife valve in the existing housings that would save a significant amount of concrete excavation work.

Recreation

Recreation benefits were determined for existing conditions and for alternative 1. The project visitation for 1984 was 31,200. Average annual recreation benefits were computed using standard discounting procedures with a 50-year project life. A conservative straight-line growth was used to develop the following information:

Existing Recreation Benefits

Year	Visitation	Unit Value	Benefits
1985	31,200	$2.84	$88,600
2000	34,000	2.84	96,560
2035	34,000	2.84	96,560

Resulting in average annual benefits at the following discount rates:

.08375 = $ 93,360 .08625 = $ 93,300

An alternative reservoir operation plan that would stabilize the pool fluctuations to the greatest extent possible, such as alternative 1, should maximize the potential recreation benefits for the reservoir. The maximum recreational development at the Orwell project would probably envision a popular sport fishery, a boat/canoe launch, parking, a swimming beach, picnicking, and toilets. It is estimated that the following additional visitation and benefits would occur only with the new facilities. The existing benefits, estimated above, would continue without additional development of recreation facilities.

Potential Additional Recreation Benefits

Year	Visitation	Unit Value	Benefits
1985	22,360	$2.96	$66,185
2000	25,000	2.96	74,000
2035	25,000	2.96	74,000

The average annual benefits result from the following discount rates:

.08375 = $ 70,835 .08625 = $ 70,800

By assigning point values to positive recreational aspects of each alternative, a total number of points were available (numeric value) for analysis of the benefits. The total point value of each alternative on a scale from 0 to 60 is shown in the attached bar graph. The points are assigned based on the target elevations and dates as shown on the alternative diagrams (Figures 20 through 28 beginning on page 68). Actual dates and elevations may vary from the diagrams because of varying hydrologic conditions.

Because specific operational hydraulic information is not available, the recreation benefits analysis used a very general method. Point values were assigned to alternatives as follows:

1. No target drawdown over 4 feet during the summer recreation season: 10 points.

2. No target fluctuation of water levels during the summer or winter recreation season: 20 points.

3. No target floodpool water level increases over 4 feet during the recreation season: 20 points.

4. A target water level change of between 4 and 8 feet during the recreation season: 10 points. (This value was only given to indicate the various water levels allowed but should not be considered seriously when providing shoreline recreation.)

5. A target water level of between 8 and 12 feet during the recreation season: 5 points. (This value was assigned only to indicate the various water levels allowed, but has no real value to shoreline recreation.)

6. Alternatives with the possibility for shorter duration and minimized fluctuation: 10 points. (Only a limited amount of information is available. Duration and times of water level fluctuations are important factors in determining shoreline recreational value.)

In the determination of monetary value for recreation benefits, each 5-point value is worth $5,900, in addition to the existing benefits of $93,300. The following table identifies the dollar value for each alternative.

Total Recreational Benefits for Each Alternative

Alternative	Total Recreational Benefits
1	$164,100
2	140,500
3	128,700
4	105,100
5	105,100
6	99,200
7	99,200
8	93,300
9	93,300

The total recreation benefit column is computed as follows:

$$\text{Total} = \underbrace{\$93{,}300}_{\text{Existing Benefits}} + \underbrace{\left(\frac{\text{Points}}{5} * \$5{,}900\right)}_{\text{Potential Additional Benefit}}$$

The point totals for each alternative that are used in this formula are taken from the following bar graph (Figure 33).

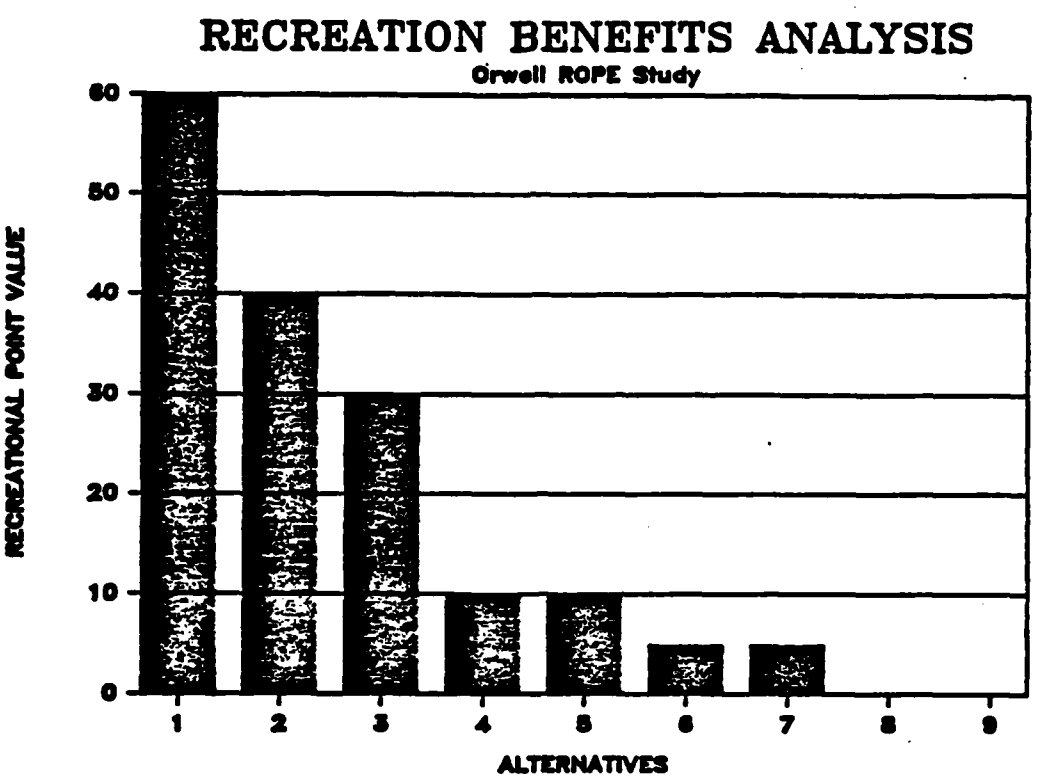


FIGURE 33 - Recreation Benefits Analysis

SUMMARY OF PLAN FORMULATION CONSIDERATIONS

Balancing the above-described water-use demands for within-reservoir conditions (reservoir stage) and instream flows (reservoir discharge) throughout the year requires seasonal changes in operating policy. A complete set of operating rules for determining daily optimum reservoir releases that would maximize project benefits would require costly real-time monitoring of reservoir inflows and stages. The operating rules would be the product of a computer model that would simulate optimum reservoir operation. Lacking this degree of predictive ability, reservoir operation plans must take the form of target rule curves, plus seasonal operating limits, for stage and discharge. The judgment of water control personnel is needed for operating decisions that allow best attainment of target reservoir stages and releases.

The following discussion of seasonal Orwell Reservoir operation and consequences is intended to describe the interactions of the various operating measures on project performance.

March to June

1. Minimize downstream flood damages

Reducing the height, frequency, and duration of discharge events in excess of 1,200 cfs would minimize flood damages.

The use of reservoir storage capacity can contribute to this main project purpose. Items 2, 3, 4, and 7 involve judicious limitation of flood storage capacity when conditions indicate lesser need for reservoir operation for flood control.

2. Delay drawdown (Figure 34)

Delaying drawdown of the reservoir pool to provide flood storage capacity for as long as possible would limit dessication of the littoral zone in the reservoir by freezing and ice damage. Many species of aquatic plants cannot withstand freezing during periods of drawdown. Precipitation conditions, downstream ice conditions, channel capacity, and reservoir drawdown rate must be considered in the decision to initiate drawdown for flood control.

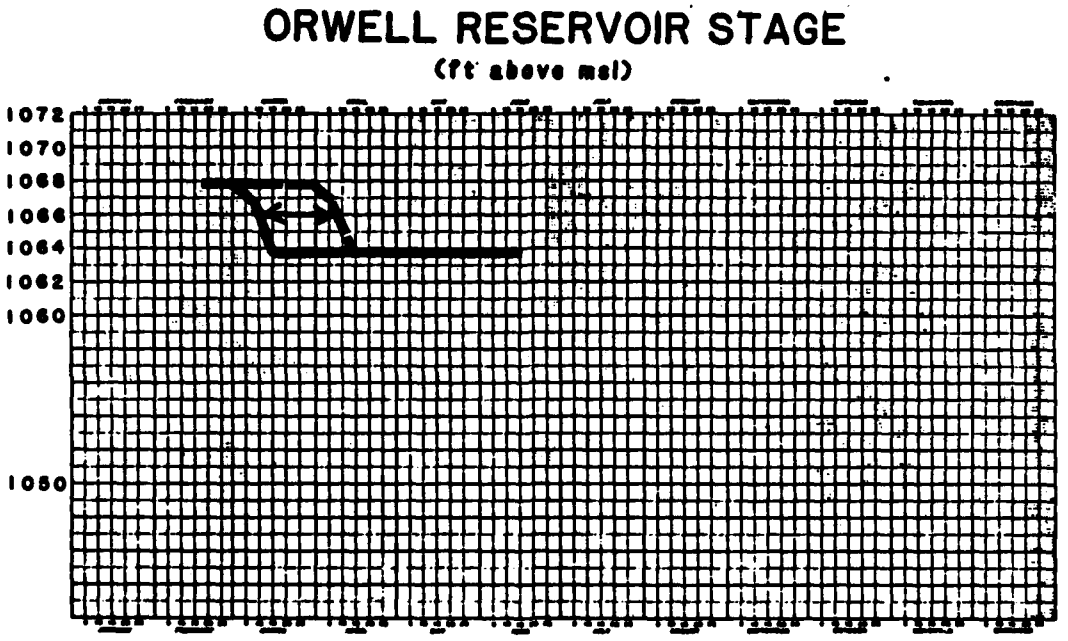


FIGURE 34 - Delay Drawdown

3. Minimize drawdown (Figure 35)

Reducing the extent of target drawdown to less than 4 feet will allow some development of the littoral zone in the reservoir. Because photic zone in Orwell reservoir only extends to 4 to 6 feet below the surface during the growing season, aquatic plant growth is restricted to this zone. To the extent that drawdown is limited to less than this depth, some aquatic vegetation can develop to provide valuable littoral habitat for other aquatic life in the reservoir.

Hydrologic conditions and storage capacity must be considered in determining necessity and depth of drawdown for flood control.

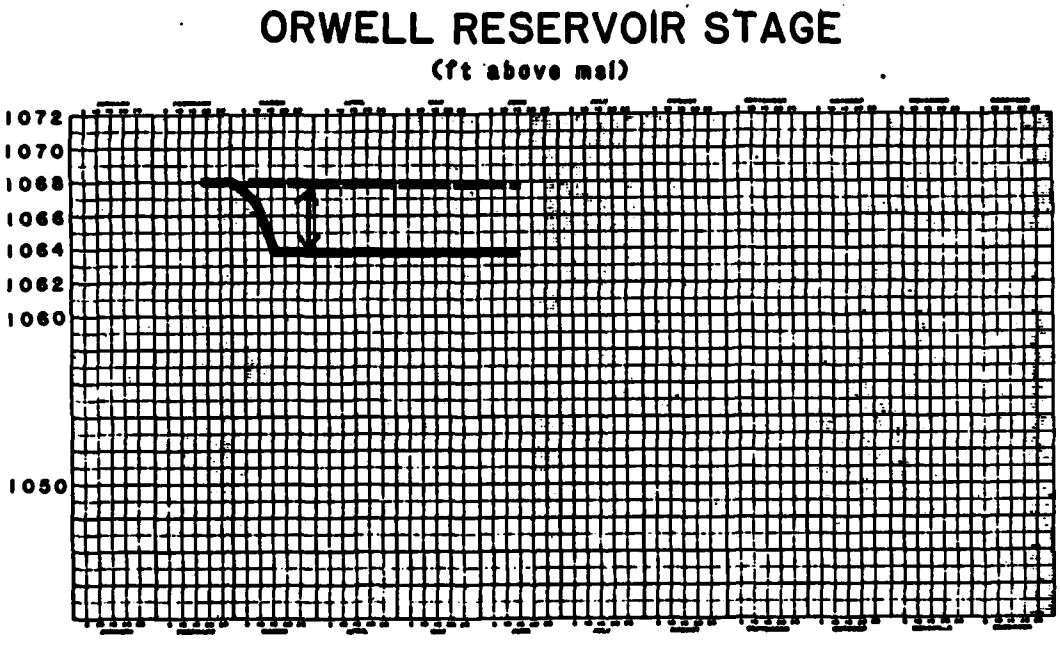


FIGURE 35 - Minimize Drawdown

4. Minimize the height and duration of flood surcharge (Figure 36)

Pool elevations above 1068 feet msl cause shoreline erosion. Extended periods of pool stage higher than 1068 msl would also limit light penetration to the littoral zone and effectively shorten the growing season within the littoral zone. Repeated periods of higher pool stages disrupt waterfowl nesting around the reservoir.

Precipitation conditions, channel capacity, amount of previous drawdown, and downstream conditions must be considered in minimizing the height, duration, and frequency of flood surcharge events.

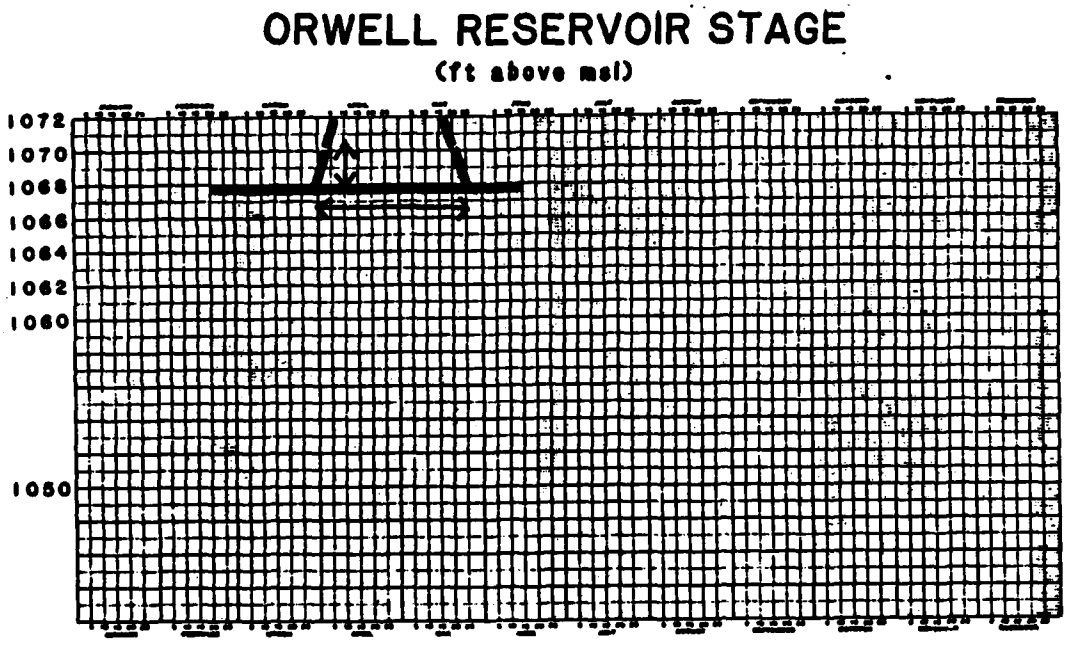


FIGURE 36 - Minimize the Height and Duration of Flood Surcharge

5. Provide flushing flows to the Ottertail River (Figure 37)

The MDNR has recommended that reservoir releases of 900 to 1,200 cfs (bank-full discharge) be made for 1 week at least once every other year to maintain good aquatic habitat conditions in the Ottertail

River below Orwell Dam (see curve A on Figure 37). Higher river discharges increase sediment transport competency and allow the scouring of hard substrates and deep holes in the streambed.

These higher flows normally occur, and intentional reservoir releases for this purpose would only need to be made after several years of lower flow conditions.

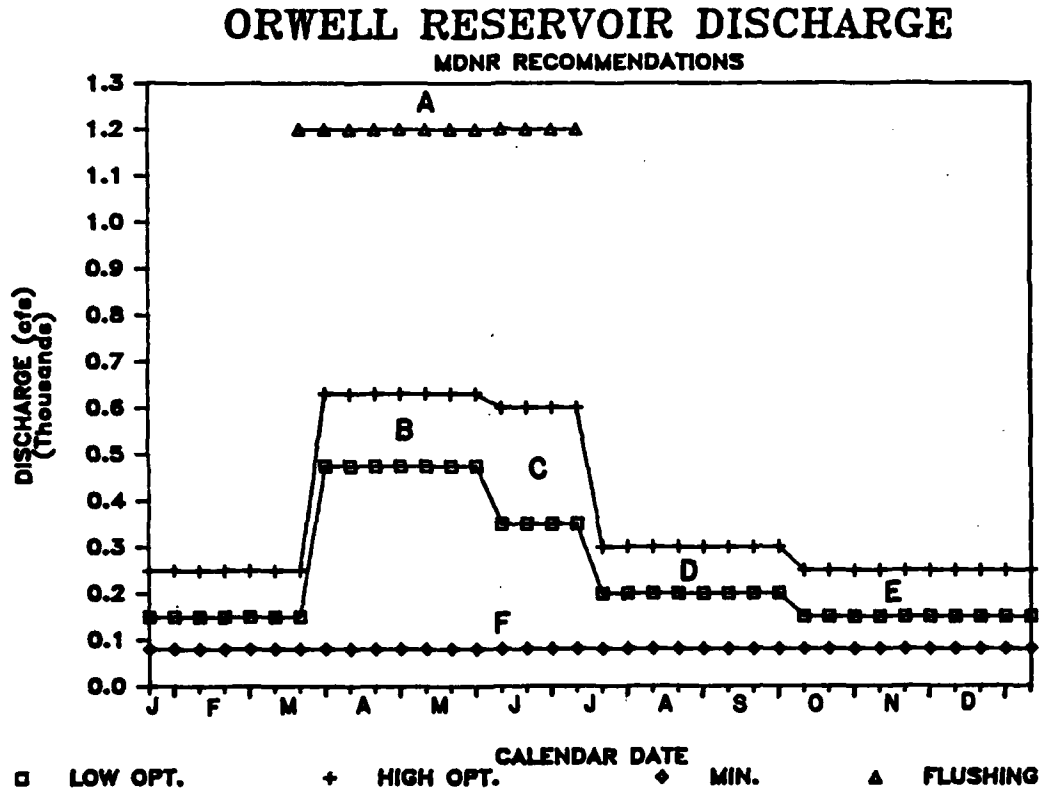


FIGURE 37 - Orwell Reservoir Discharge, MDNR Recommendations

6. Provide flows for northern pike and walleye spawning (Figure 37)

The MDNR has recommended that fairly constant discharges in the range of 470 to 630 cfs be provided for optimal spawning habitat conditions for walleye and northern pike during the period from March 20 to May 30 (see curve B on Figure 37). Flows in this range would fill downstream oxbow pools for northern pike spawing habitat

and would provide good tailwater habitat conditions for spawning walleye. Rapidly decreasing discharges during this period would strand fish eggs, larvae, and juveniles.

Ability to provide optimum instream flows for aquatic life during this time period is governed largely by reservoir inflow and antecedent drawdown/flood surcharge events in the reservoir.

7. Attain stable normal pool elevation as early as possible (Figure 38)

Although this item is essentially the same as item 4 above, earlier stable pool conditions at 1068 msl would allow better littoral zone development in the reservoir and would benefit waterfowl nesting. Repeated flood surcharge events contribute greatly to erosion of the reservoir shoreline because of the lessened stability of dewatered but saturated soil profiles.

Attaining normal (1068 feet msl) pool elevation as early as possible following the spring runoff period will be governed largely by upstream hydrologic conditions.

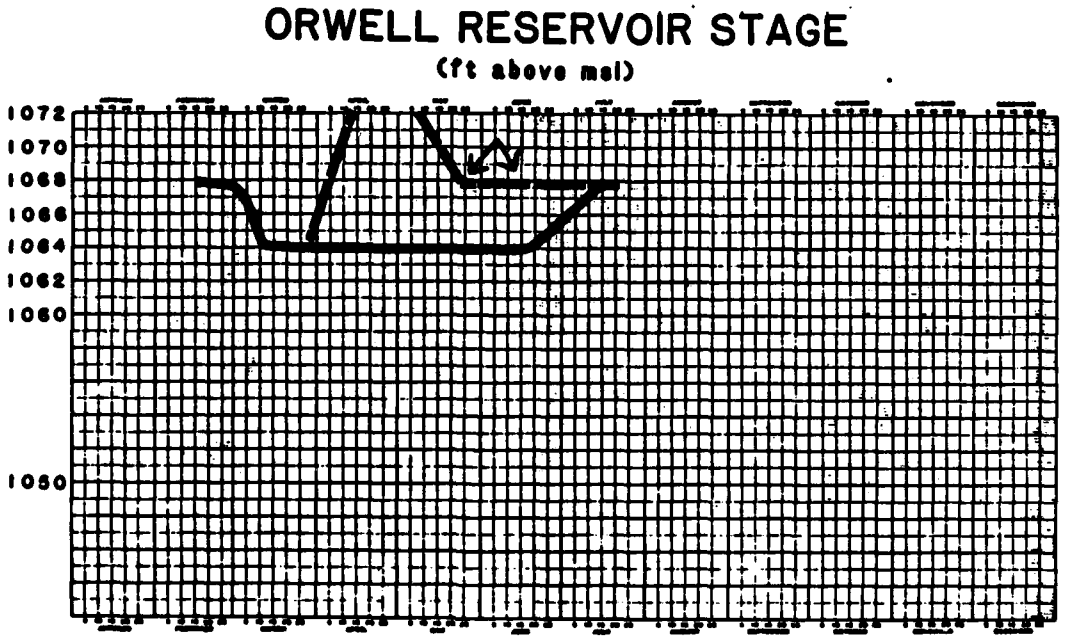


FIGURE 38 - Attain Stable Normal Pool Elevation as Early as Possible

June to July

8. Provide flows for channel catfish spawning (Figure 37)

The MDNR has recommended optimum reservoir releases in the range of 350 to 600 cfs from June 1 to July 15 to provide riverine habitat conducive to channel catfish spawning (see curve C on Figure 37, page 114).

June flows from the upper Ottertail drainage are often substantial because of storage of spring runoff in lakes and wetlands, so flows in the recommended range can be obtained in most years. Maintenance of instream flows in the recommended range during June and July would have to be balanced against reservoir stage recommendations (see item 10).

July to September

9. Provide flows for aquatic life and other instream flow needs in the Ottertail River (Figure 37)

The MDNR has recommended optimum reservoir releases in the range of 200 to 300 cfs from July 15 through August and September (see curve D on Figure 37, page 114). Gradually decreasing flows during this time would be desirable. Flows during this time should not be less than 80 cfs to protect aquatic life in the river.

Any increase in summer flows over the 80 cfs that has been the customary summer release would benefit aquatic life in the river. Providing summer instream flows for aquatic life would also meet instream flow needs for water supply, pollution abatement, and recreational boating.

10. Maintain stable summer reservoir pool elevation (Figure 39)

A stable reservoir pool elevation of 1068 msl (Figure 39) would allow development of a littoral zone in the reservoir and would provide habitat for juvenile fish. Any reduction of the drawdown zone "bathtub ring" during the summer months would also improve the aesthetic character of the reservoir for project visitors.

During summers with lower reservoir inflow, this objective will have to be balanced against releases for instream flow needs. Because the present summer operating policy would be changed from storage to release, water should be available in most years to provide for both summer instream flow needs and for fairly stable (minimum drawdown) pool elevation.

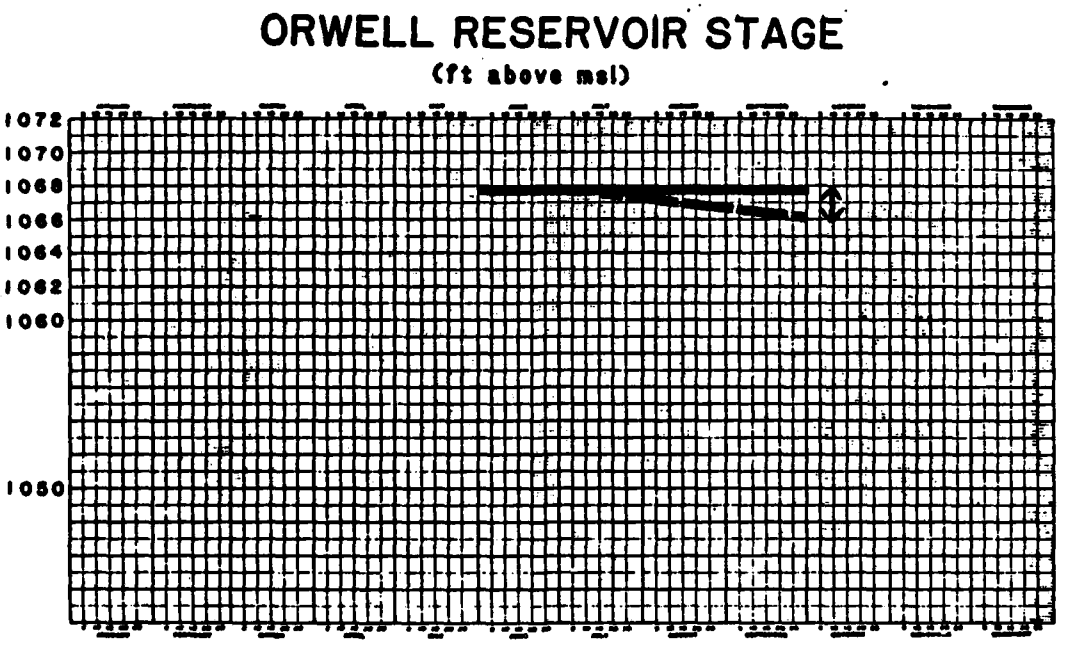


FIGURE 39 - Maintain Stable Summer Reservoir Pool Elevation

October to March

11. Maintain stable pool elevation at elevation 1068 msl (Figure 40)

Stable pool levels during the open-water portion of this period would help limit shoreline erosion. Limited pool fluctuations during the winter would improve conditions for furbearers and would prevent disruption of the littoral zone of the reservoir.

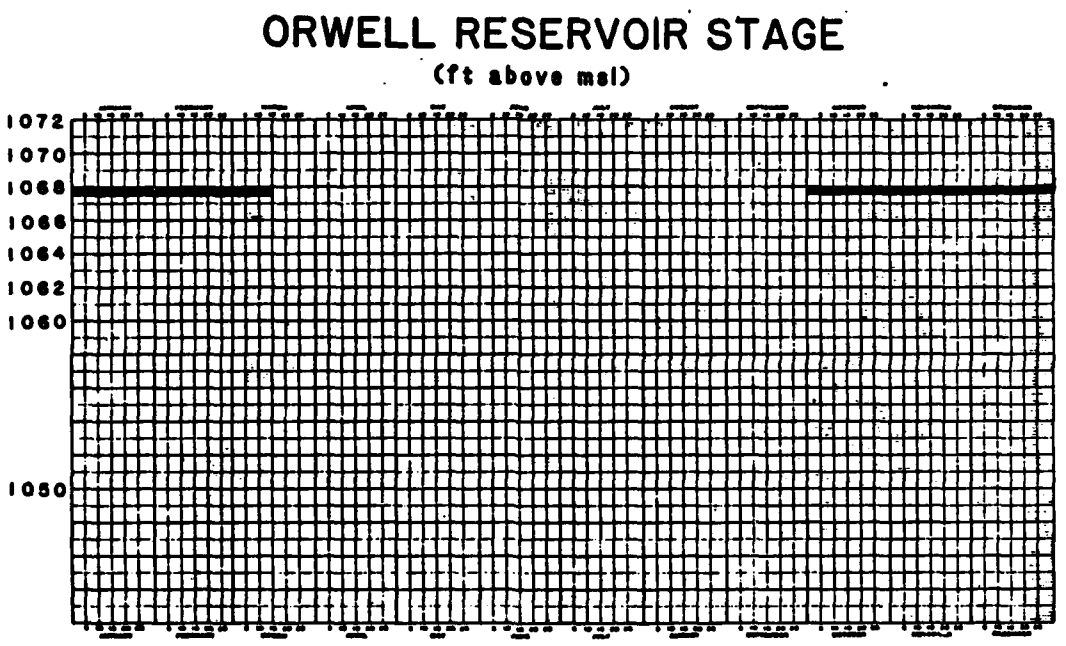


FIGURE 40 - Maintain Stable Pool Elevation at Elevation 1068 msl)

12. Provide fairly constant instream flows to protect wintering aquatic life and furbearers

The MDNR has recommended optimum flows for the period of October to March to be in the range of 175 to 250 cfs to protect wintering aquatic life in the Ottertail River. Bank-dwelling and lodge-dwelling furbearers would also benefit from stable river stages.

All Year

13. Minimum flows to protect aquatic life in the Ottertail River should be 80 cfs (Figure 37 on page 114)

    The MDNR has recommended 80 cfs as the minimum acceptable release from Orwell Reservoir, with the intent of protecting aquatic life in the Ottertail River. If severe, sustained drought conditions occur, reservoir releases would be gradually reduced from 80 cfs after 30 days of reservoir inflow of less than 80 cfs.

14. Ramp changes in reservoir releases (see table on page 59)

    The MDNR has recommended ramping rates for both increasing and decreasing discharges that should not be exceeded, with the intent of protecting aquatic life in the Ottertail River.

COMPARISON OF ALTERNATIVE RESERVOIR OPERATION PLANS

The following table summarizes the results of the evaluation activities that are described in the previous paragraphs of this section. This matrix displays the contributions of each alternative to the formally stated planning objectives, in terms of the identified indicator for each objective. The following paragraphs compare the alternatives for each objective.

Comparison of the contributions of the alternatives to urban flood damage reduction is based on the average annual dollars of benefit. The agricultural flood damage is represented by the number of acres flooded at the peak discharge. Each agricultural acre flooded represents damages in the range of $50 to $100, depending on crop type, timing, and other factors. The amount of protection varies among the alternatives because of the varying elevations that the pool is drawn down to. The lower the drawdown elevation, the greater the benefits are. However, it is surprising that the flood control benefits are relatively insensitive

COMPARISON OF ALTERNATIVES FOR ORWELL RESERVOIR

Reservoir Operation Plan Evaluation (ROPE)

Alternative Number	Urban Flood Control		Agricultural Flooding		Littoral Zone Development		Instream Flow & Pollution Abate.	Shoreline Erosion Protection	Wildlife Habitat Improvement	Recreation Benefits	Total of Dollar A.A.B. (1)	Total of Dollar A.A.B. (1)
	900 (3)	1200 (3)	900 (3)	1200 (3)	Area of 3-Foot Deep Zone Without South Arm		Average Supplemental				Using Minimum	Using Maximum
	A.A.B. (1)	A.A.B. (1)	A.A.A. (2)	A.A.A. (2)	Acres	Value of Area	Flow in cfs During July 15 to Sept 20	Provided (low,med,high)	(low,med,high)	A.A.B. (1)	Agri. Benefits $50/acre (4)	Agri. Benefits $100/acre (4)
1	$1,014	$1,279	5630	15654	195	high	0	low	high	$164,100	$948,879	$1,738,779
2	$7,657	$7,784	6234	15945	195	medium	0	medium	high	$140,500	$945,454	$1,742,784
3	$7,657	$7,784	6234	15945	190	medium	Supplemented by 25	medium	medium	$120,700	$933,654	$1,738,904
4	$9,811	$8,831	8236	15945	175-195	low	0	medium	medium	$105,500	$911,581	$1,708,831
5	$5,784	$8,831	8236	15945	175	low	Supplemented by 47	medium	medium	$105,500	$911,581	$1,708,831
6	$14,465	$14,591	8744	15945	115-195	low	0	medium	low	$99,200	$911,041	$1,708,291
7	$14,465	$14,591	8744	15945	115	low	Supplemented by 66	high	low	$99,200	$911,041	$1,708,291
8	$14,512	$14,591	10221	16083	100-195	low	0	medium	low	$93,300	$912,041	$1,716,191
9	$14,512	$14,591	10221	16083	100-195	low	Supplemented by 82	high	low	$93,300	$912,041	$1,716,191
Existing	$14,512	$14,591	10221	16083	100-200	low	Reduced by 81	low	low	$93,300	$912,041	$1,716,191

(1) A.A.B. means average annual benefits in dollars.

(2) A.A.A. means average annual acres of agricultural lands prevented from flooding compared to without-project conditions. One acre can suffer about $50 to $100 in flood damages during June.

(3) The channel capacity used for this evaluation.

(4) Using an assumed channel capacity (zero-damage discharge) of 1200 cfs.

to the drawdown elevation. The benefits only vary a maximum of about $56,000 from the best to worst flood control performance. More importantly, the 1,200 cfs channel capacity provides a significantly greater benefit than the 900 cfs capacity because it requires less reservoir storage capacity. All alternatives provide the most urban flood control benefit during the April flooding at Breckenridge and Wahpeton. The April flood peak is caused by the drainage area below Orwell Dam. The dam can reduce the contributions from the upstream areas from a range of 500 to 1,000 cfs down to 100 cfs during that period. The major agricultural benefit occurs during the June flood peaks from the drainage area above Orwell Dam. The agricultural benefits outweigh the urban benefits by a factor of at least 55 to 1.

The value of the reservoir's aquatic habitat depends heavily on the acres of and ultimate biologic value of each acre in the littoral zone. Each elevation in the reservoir represents a specific number of acres of pool area that are less than 5 feet deep, called the littoral zone. The problem is that some of the alternatives cause the pool to fluctuate so widely that little or no littoral habitat could develop. Pool fluctuations that are more than 5 feet below the proposed normal full pool of elevation 1068 msl expose the littoral zone vegetation and inhabitants to freezing or drying out. Each alternative provides a target pool fluctuation and resulting area and value of littoral zone. In some years, however, the scheduled drawdown may be exceeded (potentially, down to elevation 1048 msl) to prepare for larger flood events. In those years, the pool is also likely to stay higher for a longer period of time. This first exposes the littoral zone and then later deprives it of needed sunlight because of the thicker layer of water covering the zone. The recommended subimpoundment in the south arm would provide some 220 acres at elevation 1070 msl of high-value habitat for waterfowl production.

Instream flow and pollution abatement contributions are estimated by computing the average flow contribution from the reservoir to the inflow discharge during July 15 to September 20. The existing operation plan

reduces the average flow during that period because flows are being stored for winter pollution abatement releases which are no longer as critical as they used to be. Alternatives 1, 2, 4, 6, and 8 make no target releases during the target period, but that is still an improvement of about 80 cfs on the average over the existing plan. Alternative 9 provides the greatest target supplement. In addition, all of these alternatives tend to make a larger contribution during years with the larger floods. The flood volumes that are stored during the April and June floods are released during July, August, and September. The low-flow valves need to be replaced so that the project could provide these benefits.

Shoreline erosion is reduced by minimizing the time that the pool is above elevation 1068 msl. All alternatives except the existing plan have target elevations at and below that elevation. However, the plans that have higher target drawdown elevations would cause more frequent pool elevations above 1068. As a result, alternative 1 would provide less shoreline protection than alternatives 2 through 9. Alternative 9 provides the most shoreline protection.

Recreation development is divided into two areas. One area is based on the reservoir pool and the other on the downstream reaches of the Ottertail River. The contributions to the downstream area are represented by contributions to the instream flow category. The recreation based on the reservoir represents the existing and potential water-based and sportsman activities. The water-based activities in the reservoir become more valuable with a fairly stable pool elevation. Alternative 1 provides the most stable target pool and as a result has the most potential for water-based recreation. However, alternative 1 (and the other alternatives) would continue to be subject to pool fluctuations because flood control storage will cause the pool elevation to vary from the target elevations. Other plans that include instream-flow supplement may provide greater recreational opportunities on the Ottertail River.

Cultural resource contributions are measured by the amount of shoreline protection that is given to potentially significant cultural sites located on the tops of the eroding bluffs.

TRADEOFF EVALUATION

It is certain that no one potential reservoir operation plan could maximize benefits for all purposes at the same time. However, the net benefits of the overall project must be maximized, as required by Federal water resource policy. In order to maximize net benefits for the project, some tradeoffs among conflicting purposes have to be made. Some of the project purposes will be reduced from their maximum potential benefit levels so that other purposes will provide greater project benefits. However, the tradeoff of benefits among purposes is also constrained by a relative priority of purposes as specified in the existing congressional authority. The Minnesota Department of Natural Resources (MDNR) also has stated certain priorities among natural resource purposes at this particular project site. The MDNR priorities are used to the greatest extent practicable. Another problem is that the project contributions to the stated objectives are measured in nonstandard units. Some are in dollars, but others are not.

One tradeoff concerns the subimpoundment feature in the south arm of the reservoir. An average of about 500 acre-feet of flood control storage would be traded off for about 220 acres of high value aquatic habitat for waterfowl, furbearer, and other aquatic production. The amount of flood control storage lost each year would vary, depending on the volume of the subimpoundment pool that spring and whether the storage is actually needed. Typically, the subimpoundment pool will be at its lowest elevation in the spring when the storage is most required for flood control. The subimpoundment storage volume between elevations 1068 and 1075 will always be available for surcharge in a flood emergency. The loss of flood control storage is estimated to result in a loss of average annual flood control benefits of less than $500 for

any of the alternatives considered. The resulting increased value of waterfowl habitat was not determined in dollar values, but far exceeds $500.

Another tradeoff is best illustrated by the stacked bar chart of project benefits shown in Figure 41. The total average annual flood damage reduction (FDR), including urban and agricultural areas, is about $1.6 million. That total figure is surprisingly insensitive to the range of drawdown elevations that are represented by the range of alternatives 1 through 9. Alternative 2 would trade off a small amount of the flood control benefits that alternative 9 would realize, but the recreational benefits and other intangible benefits of alternative 2 would more than compensate for that small loss. Alternative 2 also provides the greatest net benefit.

A more fluctuating pool such as alternative 8 favors flood control and shoreline erosion protection. Alternative 9 favors instream flow contributions in addition to flood control and shoreline protection.

NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

The Principles and Guidelines, cited at the beginning of this evaluation chapter, require that an implementable national economic development (NED) plan be identified. Further, the guidelines require that the NED plan be recommended for implementation unless there is a clear and defensible rationale for deviating from the plan. In the guidelines, the NED plan is defined as the alternative that maximizes net national economic development benefits, consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. The pertinent areas of NED benefits are expressed as planning objectives in an earlier section of this report.

ORWELL BENEFIT COMPARISON

Using $100/Acre For Ag Benefits

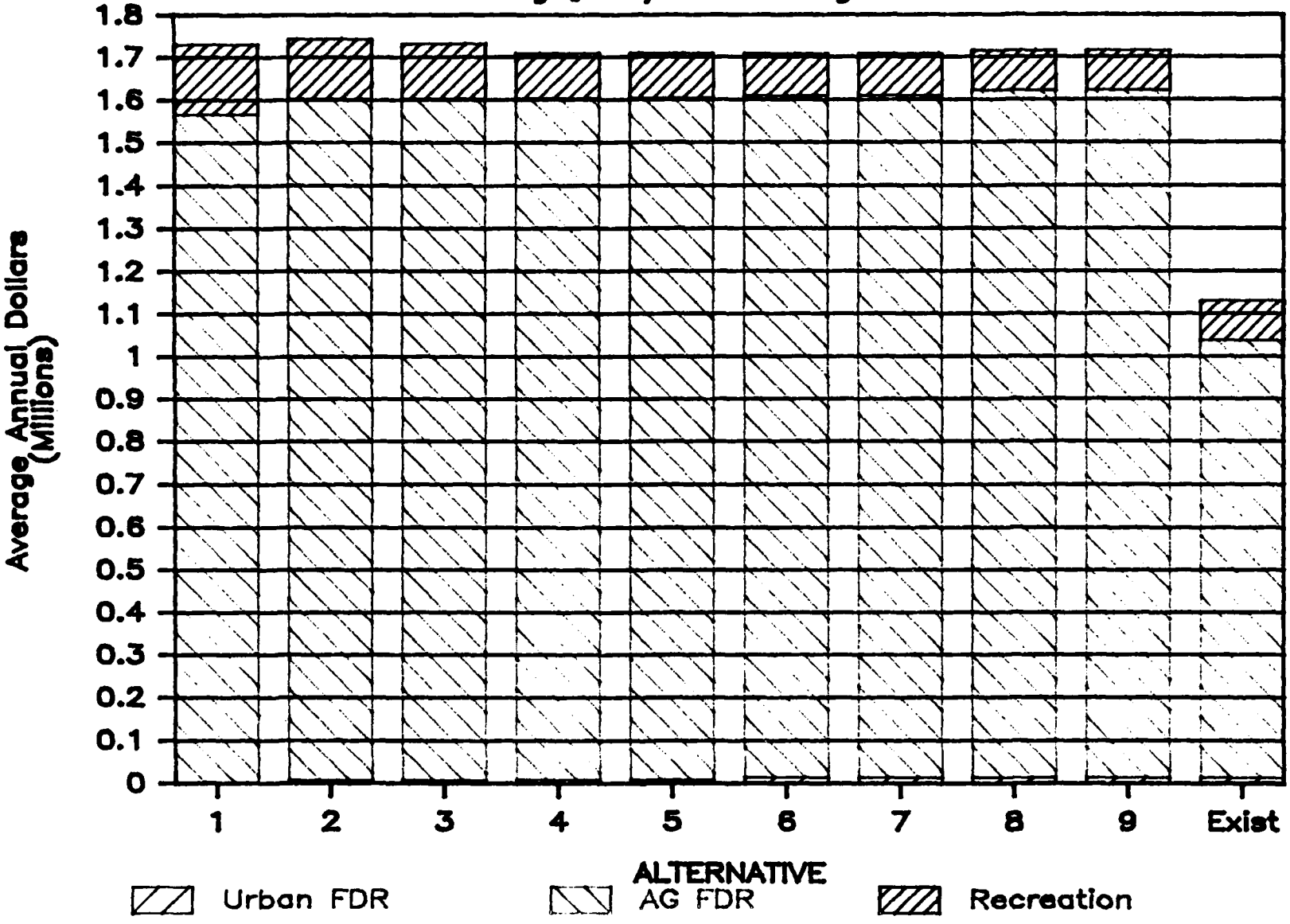


FIGURE 41

Alternative 2 would provide the greatest increase in average annual benefit over the existing plan of operation, as shown on the table on page 120. The increase would be between $350,000 and $636,000 annually. Replacement of the two low-flow valves and subimpoundment culvert is in the NED plan because these features are essential in providing the increase in benefits for alternative 2. The low-flow valve replacement is necessary to provide the required instream flows and pollution abatement benefits. The subimpoundment control is needed to provide waterfowl management for wildlife considerations and to contribute to the sportsmen's recreation benefits.

Alternative 2 is the NED plan.

PLAN SELECTION

As required by the principles and guidelines cited at the beginning of this evaluation section, this report recommends the NED plan (alternative 2) for implementation. There is no overriding reason to vary from the NED plan.

DESCRIPTION OF RECOMMENDED OPERATION PLAN

The rule curve containing the target pool elevations and dates for alternative 2 is found on page 70. The description of the use of the rule curve is on page 71. To summarize that information, the changes from the existing operation plan include the following items:

1. Increased zero-damage discharge from 900 cfs to 1,200 cfs to reflect the assumed channel capacity.

2. Rescheduled discharges for instream flow needs and pollution abatement. There are no target releases scheduled with alternative 2, but on the average this plan provides about 80 cfs more than the existing operation plan between July 15 and September 20, plus or minus a couple of weeks.

3. Increased target drawdown elevations for flood control, from elevation 1048 to elevation 1064. The target date for commencing drawdown moves from October 15 to March 1. The operation plan allows more drawdown at an earlier date if the conditions, such as heavy snow cover, require it. Drawdown for flood control can occur down to elevation 1048 and can begin sooner than March 1, if conditions require it.

4. Lowered normal full pool, from elevation 1070 to elevation 1068.

Alternative 2 includes the replacement of the two low-flow valves with two 24-inch gate valves. These valves need to be replaced with a different type of valve to eliminate a vibration problem that prevents use of the present valves over the entire range of valve openings. A temporary steel pipe attachment to the low-flow valve would be used during future dewaterings of the stilling basin for inspections or maintenance. Method 2, shown on Figure 42, is the recommended route for the temporary steel pipe extension at an estimated one-time cost of $10,000. A new low-flow structure is being considered following method 1. That alignment would eliminate the need for the temporary steel pipe extension.

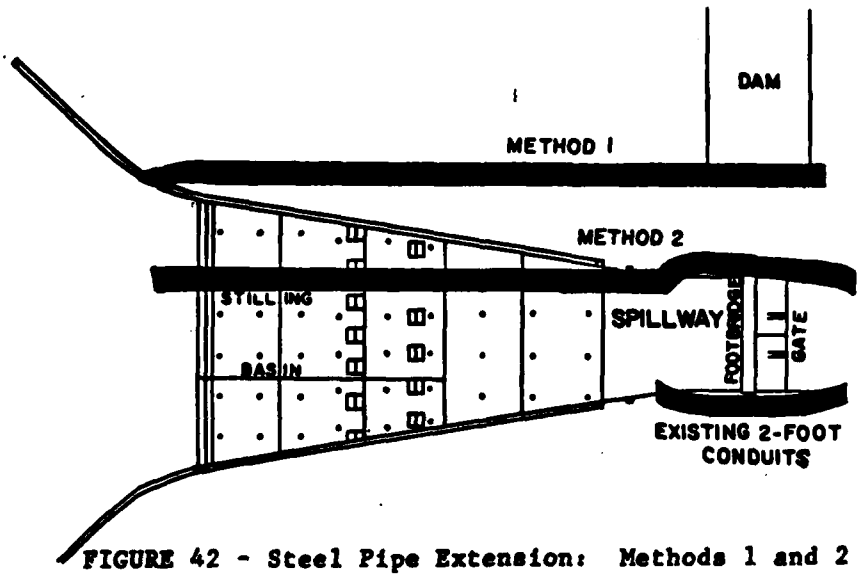


FIGURE 42 - Steel Pipe Extension: Methods 1 and 2

Also included is the replacement of the 7-foot culvert under the CSAH 2 crossing of the south arm of the reservoir. The replacement culvert is 7 feet in diameter and has a stoplog water control structure to allow management of the subimpoundment for wildlife. This structure would subimpound about 200 acres of wetland area to increase its value as waterfowl habitat. Plate 7 shows the location of the culvert in the project lands, and Plate 8 shows the design of the culvert.

Operation and maintenance of the subimpoundment control culvert would be shared between the St. Paul District and Minnesota Department of Natural Resources (MDNR). Normal operation of the flow and carp control features would be the responsibility of the MDNR. The MDNR would also be responsible for removing debris captured by either end opening of the culvert and for the appropriate disposal of debris. When the elevation of either the pool, the top of the stoplogs, or the subimpoundment exceeds elevation 1068, then the discharge control of the culvert would be coordinated with the Orwell Dam tender and ultimately with the St. Paul District Water Control Center in emergency situations. A staff gage will be installed in the stoplog well by the St. Paul District. Normal maintenance and repair of the culvert would be the responsibility of the St. Paul District. The grating at the top of the stoplog well would be secured, and keys would be issued to the Orwell Dam tender and the MDNR area wildlife manager for use by their crews. When the grating is unsecured for operation or maintenance, appropriate safety precautions should be taken to protect all personnel at the site.

It is also recommended that the proposed operation plan be tested for Orwell Reservoir to determine whether that plan is appropriate for permanent implementation. A 3- to 5-year test period, starting in 1986, would likely be used as has been done at other Corps-operated reservoirs in the St. Paul District. The St. Paul District Water Control Center would initiate the update of the reservoir regulation manual when the proposed operation plan has been sufficiently tested.

IMPLEMENTATION ACTIVITIES

The following paragraphs summarize the remaining work to implement the proposed reservoir operation plan. The operation plan needs to be tested using the entire hydrologic period of record to ensure that the plan satisfies all engineering and safety aspects of reservoir operation. An existing HEC-5 model could be used to do that. Any resulting refinements of the plan need to be considered in a refinement of plan formulation work. Corps of Engineers copies of this ROPE report contain a cost estimate of all proposed implementation activities on the last page before the back cover. Funding for these activities would be programmed into the Corps of Engineers Construction-Operations budgetary process for possible future funding, depending on national priority.

HYDROLOGIC MONITORING

During the testing of the proposed operation plan, the hydrologic conditions affected by the project need to be monitored. The factors include channel capacity, ice jam potential, and the accuracy and effectiveness of the rule curve. A hydraulic reconnaissance person may need to spend up to 5 days a year in the field and about the same period in the office working on this plan.

PUBLIC COORDINATION

During the testing of the proposed operation plan, coordination will need to continue concerning the project effects and environmental concerns. The coordination will be much less intense than was conducted for this report. Much of it will likely be with the Minnesota Department of Natural Resources concerning the subimpoundment and other environmental considerations, such as a management plan for the Orwell Wildlife Refuge. The downstream cities and other interested parties may also require some minor coordination.

HEC-5 MODELING

A more detailed hydrologic evaluation is required. The period of record of flows into the reservoir should be run through the existing Red River basin HEC-5 computer model for the Ottertail River subarea using the existing and recommended operation plans and a few close alternatives. This evaluation would assure that the recommended operation plan meets all the engineering and safety criteria for operation of Federal reservoirs. Also, the economic evaluation of project benefits will be refined using the updated hydrographs. The North Central Division comments concerning the seasonality of agricultural benefits will be resolved using the updated hydrologic evaluation.

WATER QUALITY EVALUATION

The Corps of Engineers Waterways Experiment Station (WES) has developed several empirical eutrophication models that are useful for some aspects of reservoir water quality assessment and management. It is proposed to use the methods developed by WES to investigate water quality conditions for various changes in pool elevations of Orwell Reservoir. These changes in pool elevation cause significant changes in reservoir morphometry (especially mean depth and hydraulic residence time), which influence water quality.

Parameters to be investigated include chlorophyll-a, transparency, and hypolimnetic oxygen depletion rate. Recommendations would then be made on which pool elevation would result in optimum water quality conditions.

SHORE STABILIZATION BY PLANTING VEGETATION

Willow cuttings would be planted along the base slopes of several eroding banks during the first year. A photographic record of the condition of eroding banks and plantings would be maintained. If the initial limited-scale plantings prove successful, larger-scale planting

efforts would be made with the aid of volunteers for harvesting and planting cuttings.

ACTIVITY SCHEDULE

Draft Orwell ROPE Report	October 1985
Final Orwell ROPE Report	December 1985
Update Orwell Reservoir Regulation Manual	Between 1989 and 1991

The Orwell Reservoir regulation manual had been tentatively scheduled for routine update in fiscal year 1987. However, that work will be delayed until sometime during the period 1989 to 1991, until the selected operation plan has been sufficiently tested. Within that time, a decision is expected to be made whether to go back to using the existing operation plan or to permanently implement alternative 2. It is not economically efficient to update the regulation manual now and then again within 3 to 5 years.

RECOMMENDATIONS

This report contains supporting documentation for a number of important recommendations concerning the operation of the Orwell project.

It is recommended that:

1. The testing, implementation activities, and monitoring of the new operation plan (alternative 2), as described in this report, be initiated in fiscal year 1986.

2. The existing recreation master plan be updated in fiscal year 1986 or 1987 to determine the feasibility of additional recreation features and to identify potential cost share sponsors.

3. A ROPE study be considered for Lake Traverse. A problem appraisal report, estimated to cost $25,000, should be accomplished before any significant detailed evaluation is done.

4. The St. Paul District work more closely with the Minnesota Department of Natural Resources (MDNR) in developing a wildlife habitat management plan for project lands. The lease agreement with the MDNR does not relieve the District of its responsibility to ensure that project lands are utilized to their maximum potential. The MDNR area wildlife manager has indicated that it would be desirable to better coordinate the plan.

5. The assumed zero-damage discharge from Orwell Dam be increased from 900 cfs to at least 1,200 cfs.

6. The normal full pool elevation be decreased from elevation 1070 msl to elevation 1068 feet msl.

7. The south arm subimpoundment control structure be constructed in fiscal year 1986 at a Federal cost of $15,000 and its operation be coordinated with the Minnesota Department of Natural Resources as described in this report.

8. The two 24-inch low-flow control valves be replaced at a Federal cost of $70,000, during the 1986 construction season, as part of the normal maintenance of this project.

9. Periodic inspections of the stilling basin area be accomplished while allowing a nominal flow to continue in the Ottertail River using temporary steel pipe extensions of the low-flow outlets at a cost of about $10,000, as described in this report.

10. The Orwell Dam tender relay significant discharge change orders to the Breckenridge City Engineer, presently Mr. Dave Freitag, at telephone (218) 643-1431.

11. The St. Paul District submit a Real Estate Design Memorandum to the Office of the Chief of Engineers for approval to acquire approximately 30 acres of private land as a solution to the encroachment problem encountered at the one area.

Joseph Briggs
Colonel, Corps of Engineers
District Engineer

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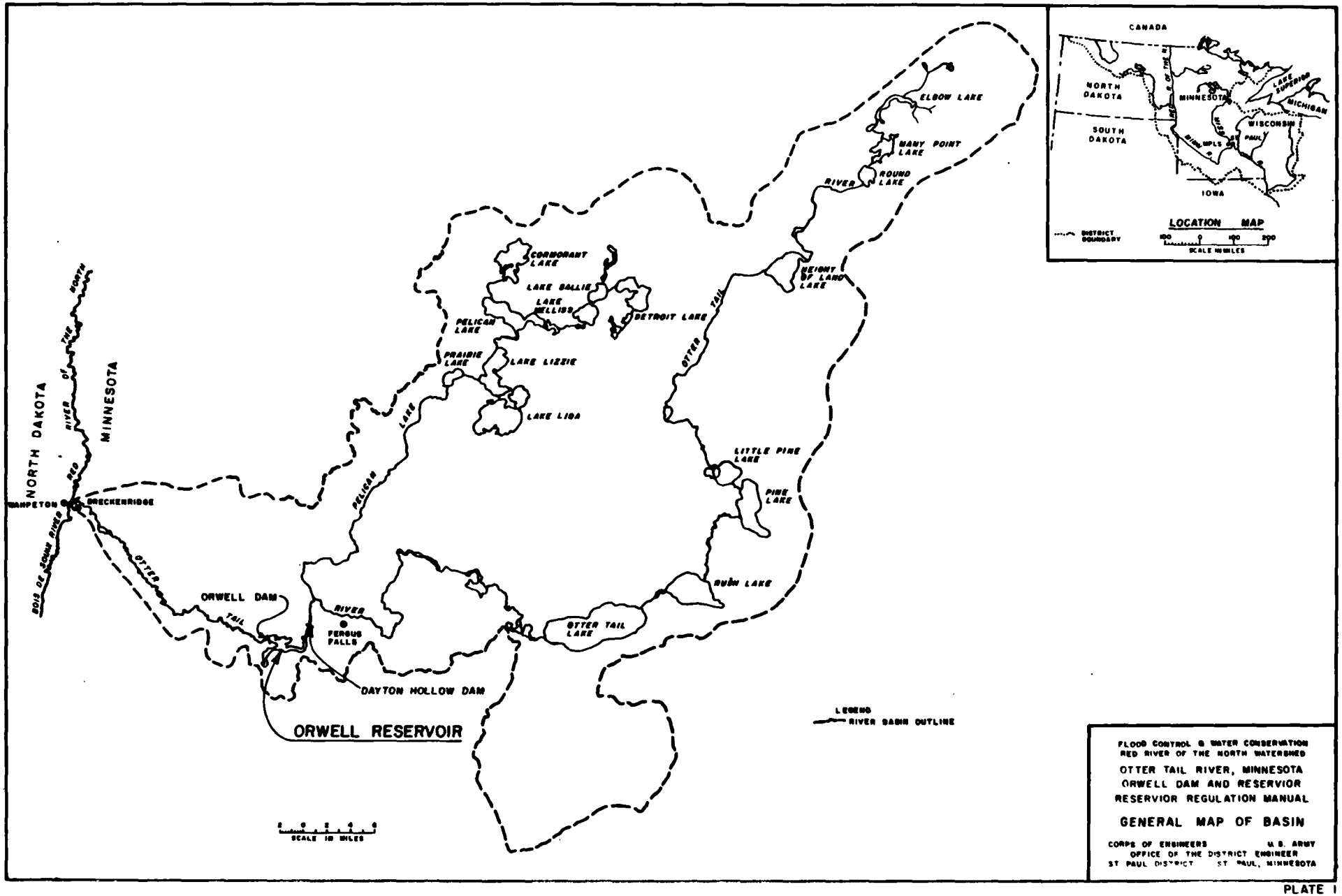

CANADA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
IOWA
WISCONSIN
MICHIGAN
LAKE SUPERIOR
LOCATION MAP
DISTRICT BOUNDARY
SCALE MILES
ELBOW LAKE
MANY POINT LAKE
ROUND LAKE
RIVER
HEIGHT OF LAND LAKE
CORMORANT LAKE
LAKE SALLIE
LAKE MELLISS
DETROIT LAKE
OTTER TAIL
PELICAN LAKE
PRAIRIE LAKE
LAKE LIZZIE
LAKE LIDA
LITTLE PINE LAKE
PINE LAKE
RUSH LAKE
OTTER TAIL LAKE
PELICAN
LAKE
NORTH DAKOTA
MINNESOTA
RED
RIVER OF THE NORTH
WAHPETON
BRECKENRIDGE
BOIS DE SIOUX RIVER
OTTER TAIL
ORWELL DAM
RIVER
FERGUS FALLS
DAYTON HOLLOW DAM
ORWELL RESERVOIR
SCALE IN MILES
LEGEND
RIVER BASIN OUTLINE
FLOOD CONTROL & WATER CONSERVATION
RED RIVER OF THE NORTH WATERSHED
OTTER TAIL RIVER, MINNESOTA
ORWELL DAM AND RESERVOIR
RESERVOIR REGULATION MANUAL
GENERAL MAP OF BASIN
CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST. PAUL, MINNESOTA

PLATE I

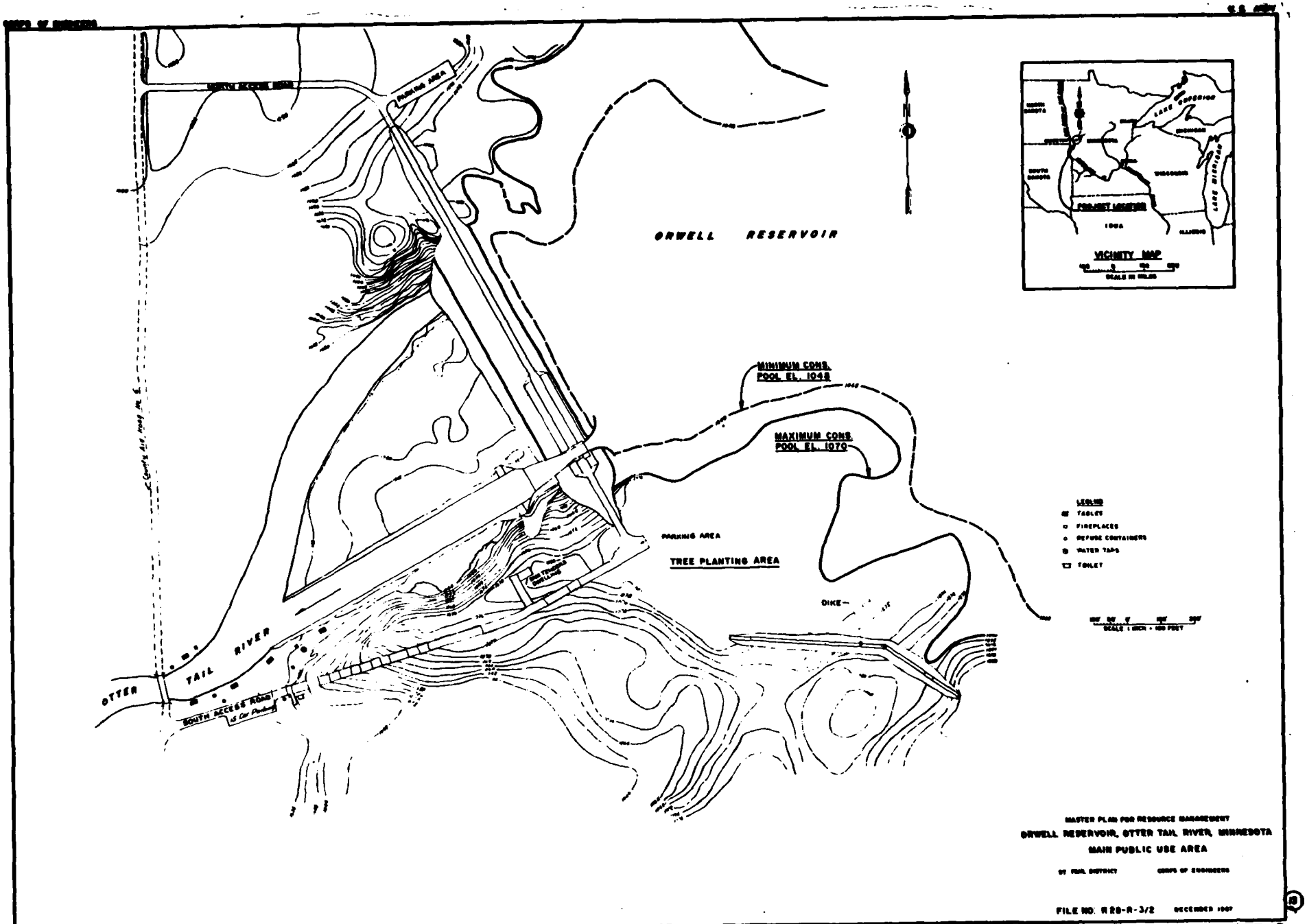

ORWELL RESERVOIR
MINIMUM CONS. POOL EL. 1048
MAXIMUM CONS. POOL EL. 1070
PARKING AREA
TREE PLANTING AREA
DIKE
OTTER TAIL RIVER
SOUTH ACCESS ROAD
VICINITY MAP
LEGEND
TABLES
FIREPLACES
REFUSE CONTAINERS
WATER TAPS
TOILET
MASTER PLAN FOR RESOURCE MANAGEMENT
ORWELL RESERVOIR, OTTER TAIL RIVER, MINNESOTA
MAIN PUBLIC USE AREA
FILE NO. R28-R-3/2 DECEMBER 1967

PLATE 2

CORPS OF ENGINEERS

U.S. ARMY

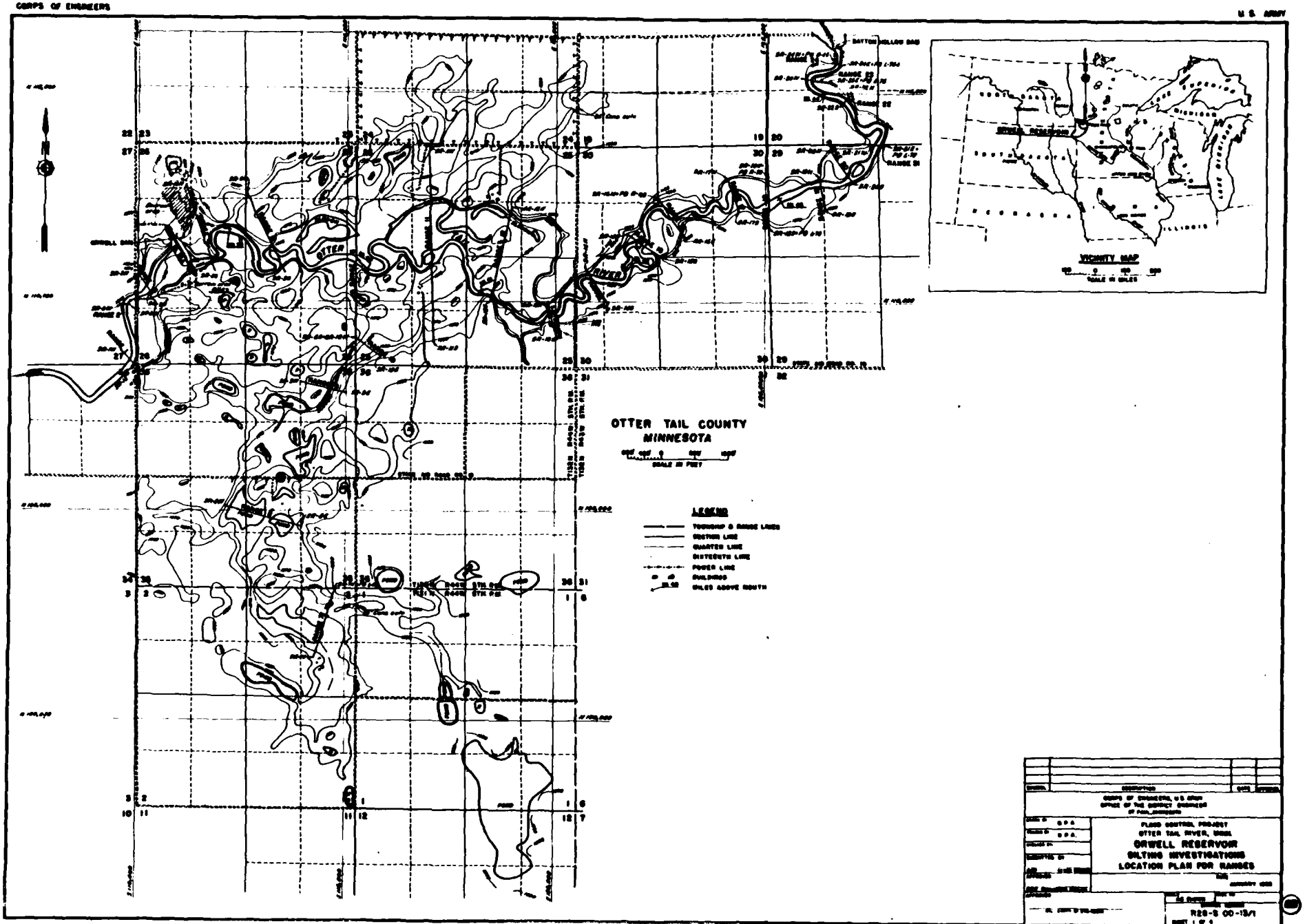
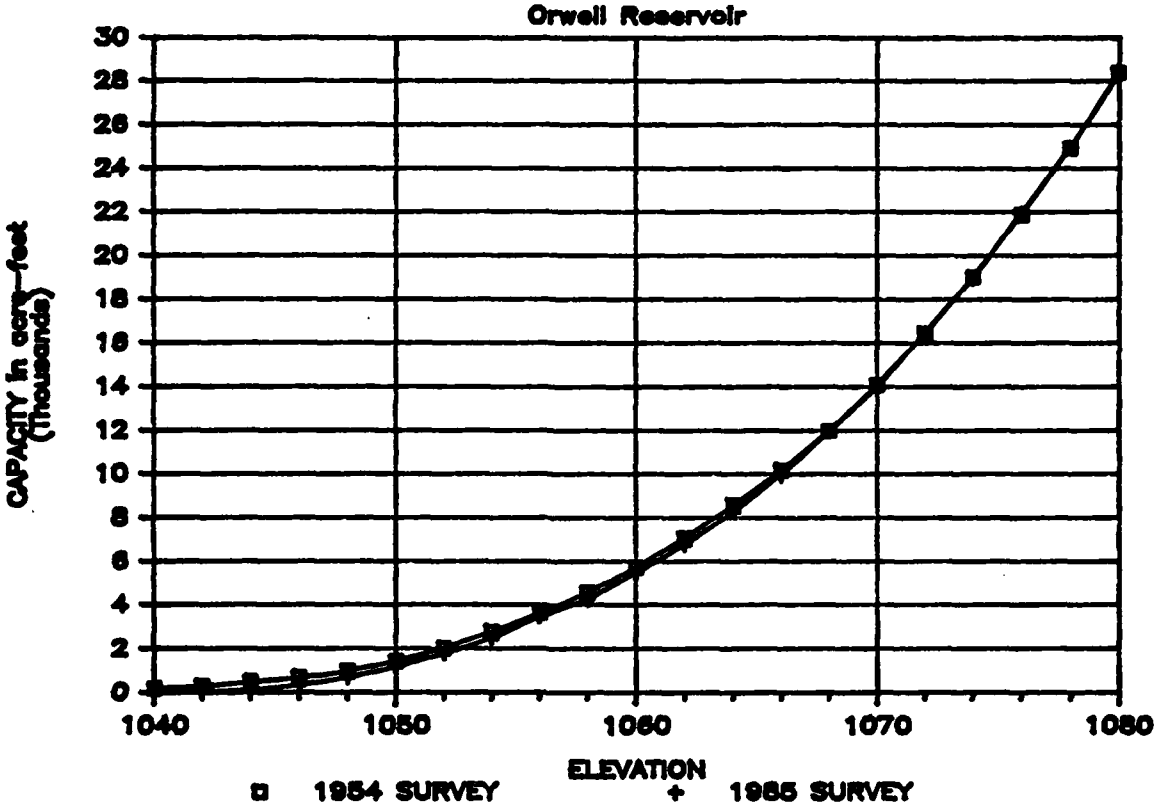


PLATE 3

STORAGE CAPACITY CURVE

Orwell Reservoir



STORAGE CAPACITY CURVE

Orwell Reservoir

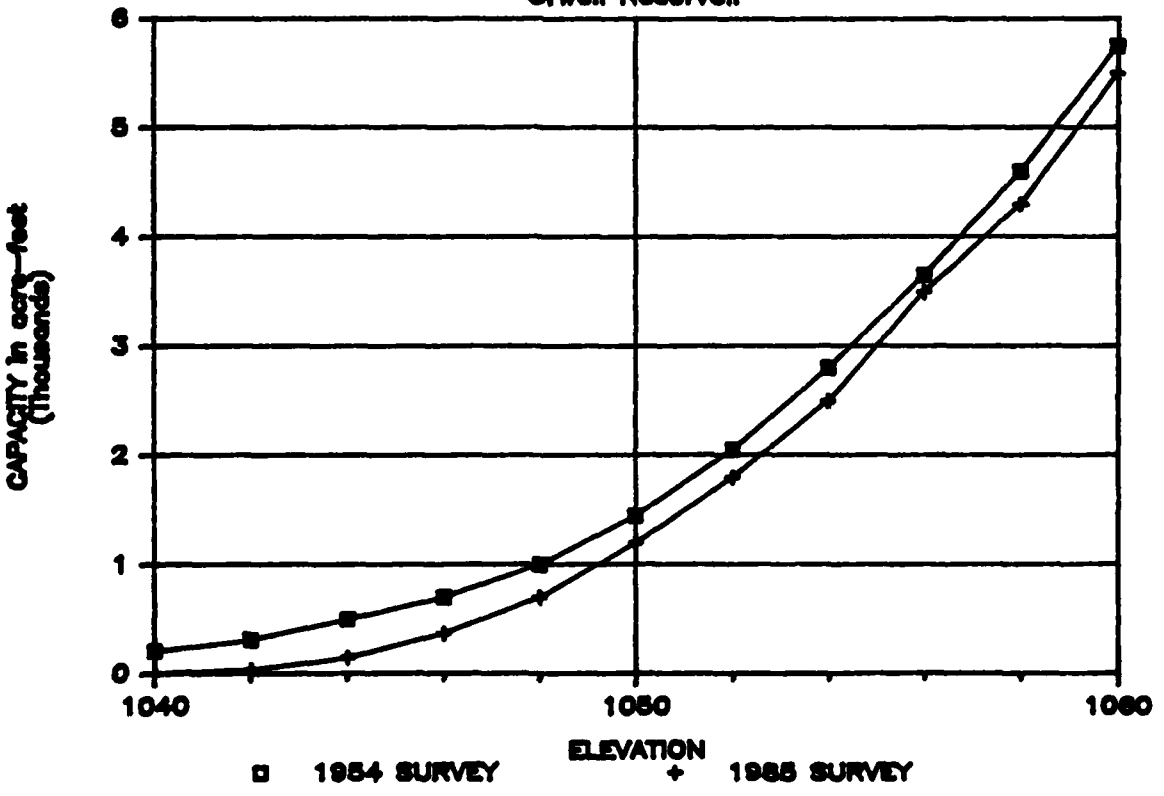
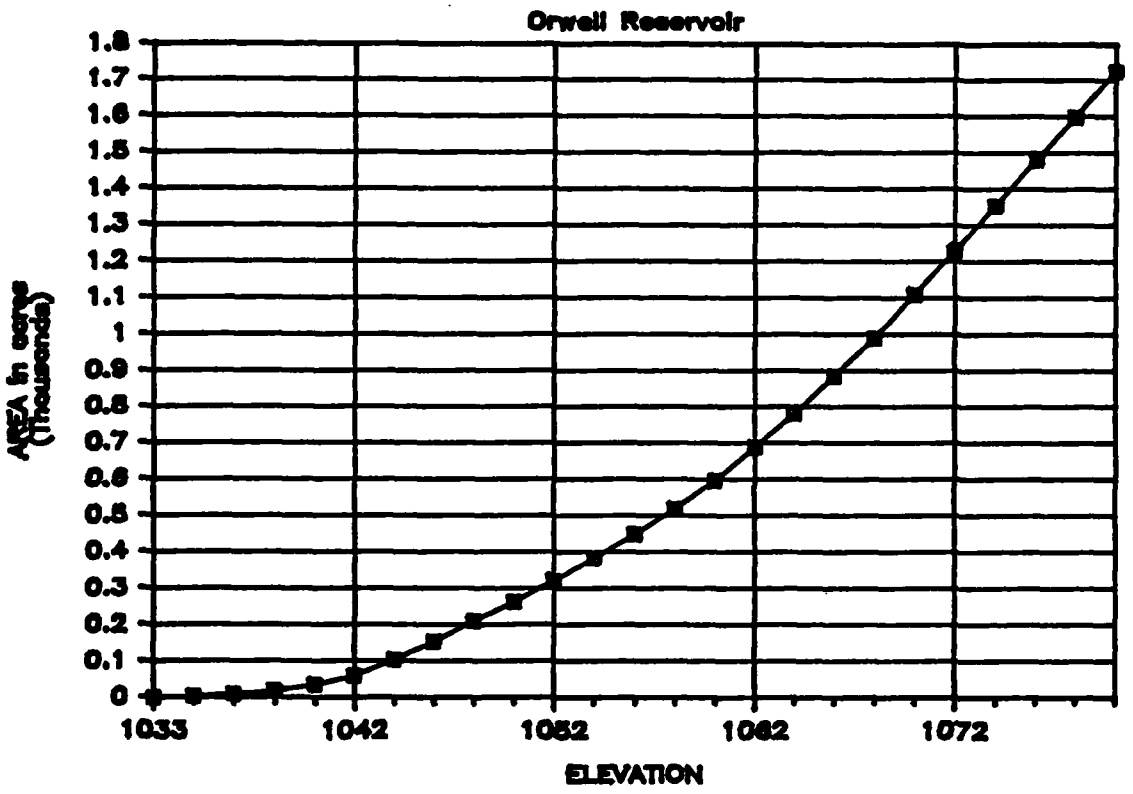


PLATE 4

AREA–ELEVATION CURVE



Elevation	Area Acres
1033	0
1034	4
1036	10
1038	19
1040	35
1042	60
1044	104
1046	155
1048	210
1050	264
1052	322
1054	384
1056	450
1058	520
1060	598
1062	690
1064	782
1066	887
1068	990
1070	1110
1072	1230
1074	1355
1076	1480
1078	1600
1080	1725

PLATE 5

DISCHARGE – FREQUENCY CURVE

INFLOW TO ORWELL RESERVOIR

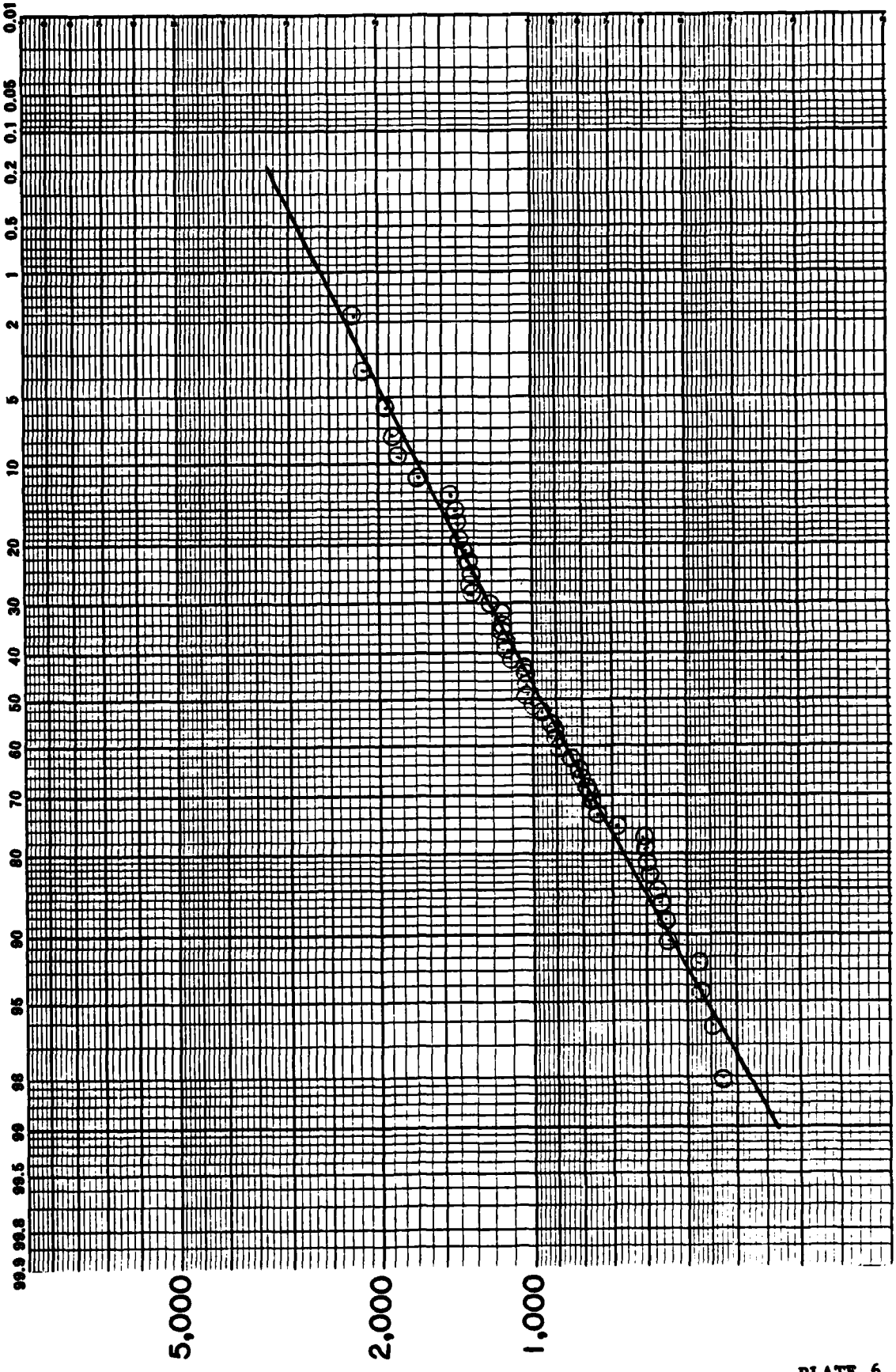
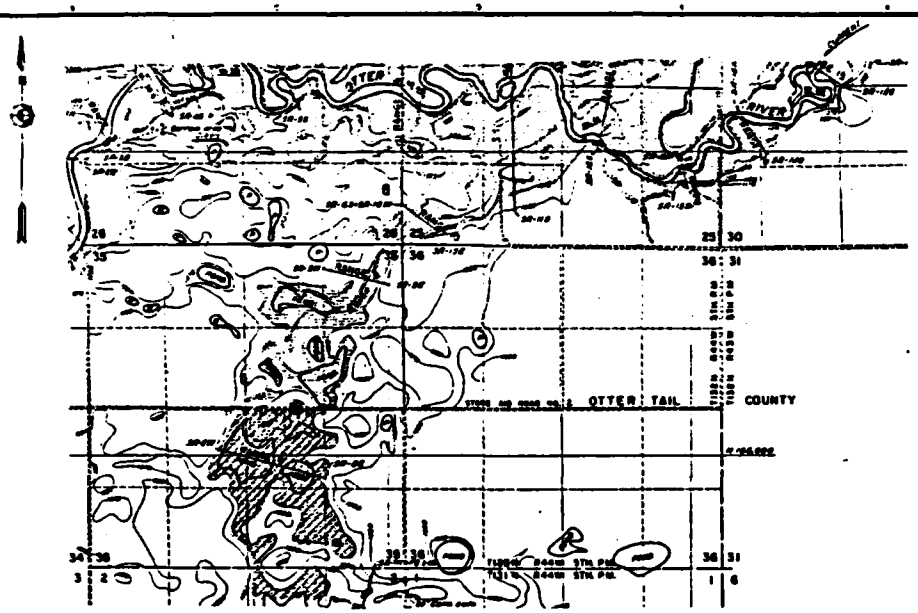
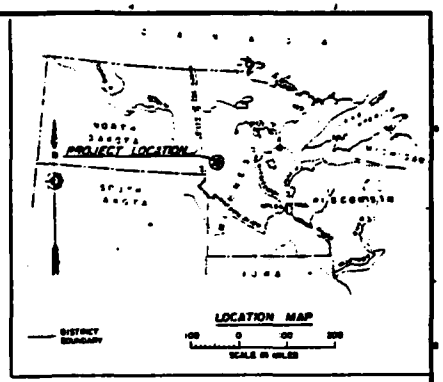


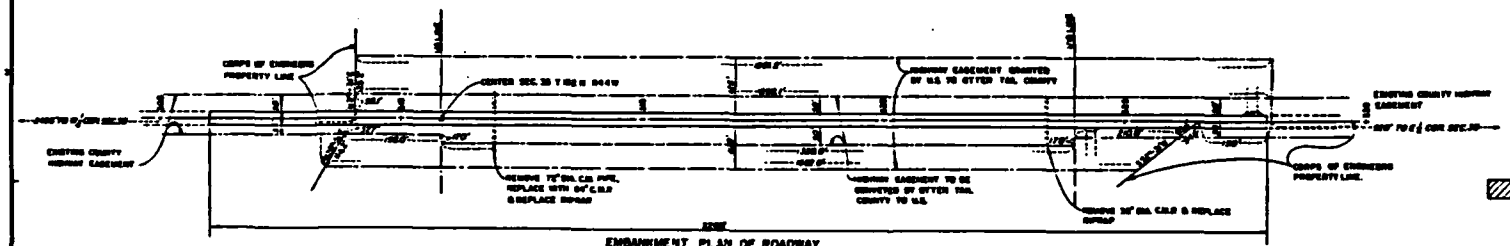
PLATE 6



VICINITY MAP

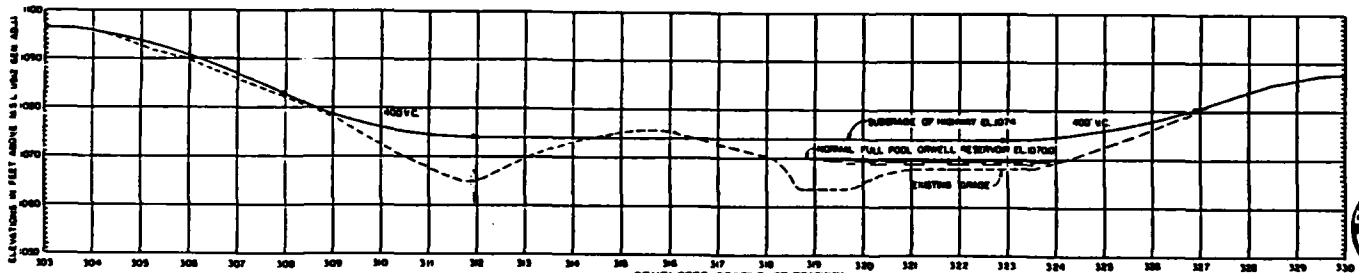
SCALE IN FEET





EMBANKMENT PLAN OF ROADWAY

SCALE IN FEET



DEVELOPED PROFILE OF ROADWAY

SCALE IN FEET

DEPARTMENT OF THE ARMY

ORWELL RESERVOIR OPERATING PLAN

MAINTENANCE - OTTER TAIL RIVER

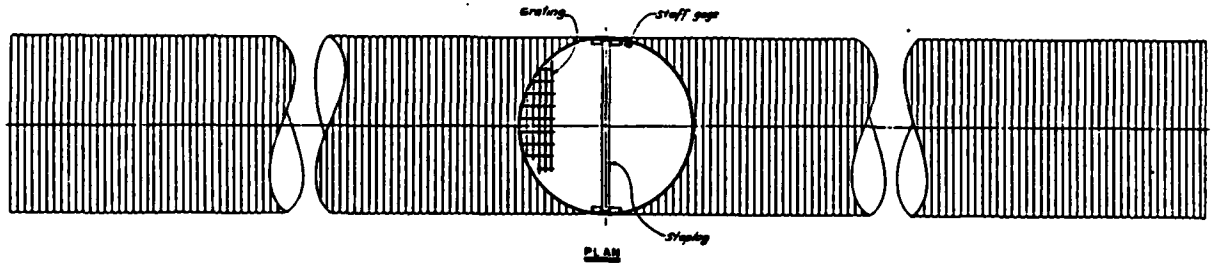
FERGUS FALLS MINNESOTA

RESERVOIR SUBIMPOUNDMENT

PLAN AND PROFILE

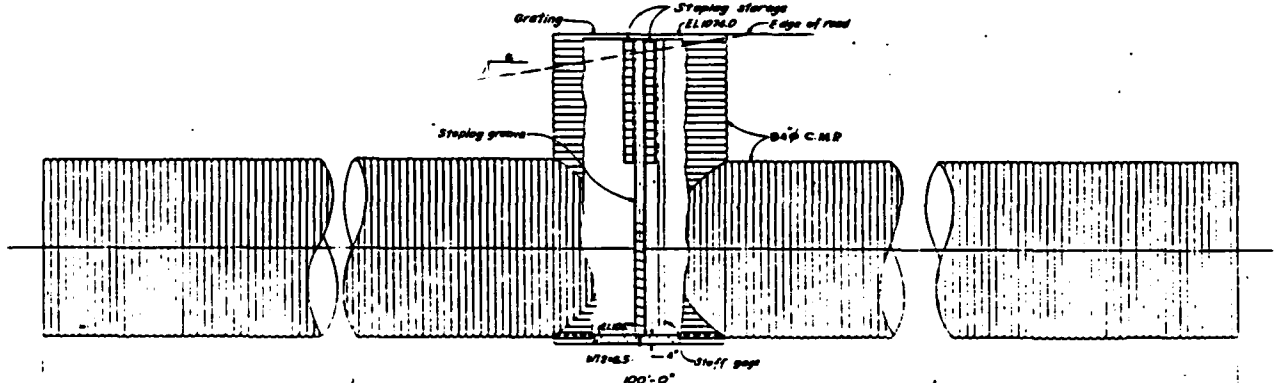
OCTOBER 1980

PLATE 7



PLAN

STOP LOG



FRONT ELEVATION

USE EXISTING INVERT ELEVATIONS

INLET (SOUTH END) EL. 1061.4

DEPARTMENT OF THE ARMY

RESERVOIR SUBIMPOUNDMENT

CMP CULVERT DETAIL

PLATE 8

PERTINENT DATA

General

Total drainage area	1,820 square miles
Effective drainage area (below main lake region)	245 square miles

Reservoir

Pool elevation at spillway design flood	1075.0	feet msl
Capacity at spillway design flood elevation	20,400	cfs
Normal full pool elevation	1068.0	feet msl
Normal low pool elevation	1048.0	feet msl
Fee title to elevation	1073.0 ±	feet msl
Capacity at normal full pool (elevation 1068.0)	12,000	acre-feet
Capacity at normal low pool (elevation 1048.0)	1,000	acre-feet
Effective storage capacity	11,000	acre-feet
Reservoir area at normal full pool	990	acres
Reservoir area at normal low pool	210	acres
Reservoir length at normal full pool	4.0	miles
Maximum reservoir width at normal full pool	1.0	mile

Dam

Type	Rolled earth fill	
Crest elevation	1080.0	feet msl
Maximum height	47	feet
Top width	20	feet
Length of earth fill	1,355	feet
Embankment side slopes	1 on 3	
Total volume of earth fill	168,165	cubic yards
Freeboard above maximum elevation of spillway design flood	5.0	feet

Dikes

Number	2	
Crest elevation	1080.0	feet msl
Maximum height	10	feet
Total length	1,140	feet
Total volume of earth fill	9,521	cubic yards

Spillway

Type	Gated ogee and chute	
Crest elevation	1044.0	feet msl
Length of spillway crest	33	feet
Elevation top of tainter gate (closed)	1071.5	feet msl
Design discharge (surcharge 5 feet)	20,400	cfs
Volume of concrete in structure	9,310	cubic yards

PERTINENT DATA (Continued)

Outlet Works

Low Water Control

Size	2 feet inside diameter
Number	2
Invert elevation	1040.0 feet msl
Discharge capacity (total for both gates) at normal full pool (1070.0)	150 cfs
Gates	Two hand-operated 24" AWWA M&H iron body double disc gate valves
Recommended replacement gates	Two 24" butterfly valves

Stilling Basin

Type	flared
Length	72 feet
Floor elevation	1024.5 feet msl
Elevation of end sill	1032.5 feet msl
Maximum width at end sill	78.5 feet

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1135 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101-1479

REPLY TO
ATTENTION OF
Environmental Resources Branch
Planning Division

FINDING OF NO SIGNIFICANT IMPACT

In accordance with the National Environmental Policy Act of 1969, the St. Paul District, Corps of Engineers, has assessed the environmental impacts of the following proposed action:

Orwell Reservoir
Operational Improvements
Ottertail River, Otter Tail County, Minnesota

The proposed work involves a 5-year trial period for a revised reservoir operating plan, creation of a 220-acre subimpoundment for wildlife management, and improvements to the low-flow conduits in the dam.

The revised reservoir operating plan would greatly reduce pool fluctuations, increase controlled releases to channel capacity, and augment summer flows in the Ottertail River for aquatic life, recreation, pollution abatement, and water supply. The revised operating plan for the Orwell Reservoir project would provide greater public benefits because of improved project operation.

Based on information in the environmental assessment for operational improvements at Orwell Reservoir, I have determined that the proposed action would not be a major Federal action that would significantly affect the human environment. An environmental impact statement will, therefore, not be prepared.

20 Feb. 1986
Date

Joseph Briggs
Colonel, Corps of Engineers
District Engineer

ENVIRONMENTAL ASSESSMENT

ORWELL RESERVOIR
OPERATIONAL IMPROVEMENTS
OTTERTAIL RIVER
OTTER TAIL COUNTY, MINNESOTA

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479
January 1986

ENVIRONMENTAL ASSESSMENT
ORWELL RESERVOIR
OPERATIONAL IMPROVEMENTS
OTTERTAIL RIVER
OTTER TAIL COUNTY, MINNESOTA

1.00 PROJECT DESCRIPTION

Location

1.01 Orwell Reservoir is in west-central Minnesota, in Otter Tail County, about 6 miles southwest of Fergus Falls (see figure 1, Reservoir Operation Plan Evaluation (ROPE) study report).

Project Features

1.02 The principal existing project features are an earth-fill dam, a combined spillway and outlet structure, and two low perimeter dikes. The reservoir covers 1,110 acres at normal pool elevation. About 1,985 acres of Federal land surround the reservoir, including 1,957.6 acres that are leased to the Minnesota Department of Natural Resources (MDNR) and actively managed for wildlife.

Authority and Project Purpose

1.03 Orwell Dam is part of a comprehensive flood control plan for the Red River of the North drainage basin, authorized by Flood Control Acts passed on June 30, 1948, and May 17, 1950. Project construction began in 1951, and reservoir operation began in 1953. The reservoir provides flood protection for agricultural land and for the cities of Wahpeton, North Dakota, and Breckenridge, Minnesota.

Need for Proposed Action

1.04 Changed Conditions Since Project Construction - Water use demands for Orwell Reservoir have changed considerably since the project was built. A problem appraisal report prepared by the St. Paul District in February 1985 identified a number of problems, needs, and opportunities for reservoir operation. The ROPE report describes in detail the shortcomings of present reservoir operation.

1.05 Problems Related to Pool Elevation - Large pool level fluctuations associated with the present reservoir operating plan contribute to problems that diminish project benefits. Shoreline erosion is severe along 35 percent of the shoreline. This erosion is caused partly by wave action and partly by widely fluctuating water levels. The shoreline erosion impairs water quality, destroys riparian vegetation, encroaches on private property, and is aesthetically displeasing. Pool fluctuations have prevented development of vegetation and associated aquatic life in the littoral zone, thereby limiting habitat value for fish and wildlife. Pool fluctuations have also reduced habitat quality in peripheral wetlands around the reservoir by inhibiting emergent vegetation and waterfowl nesting. The extensive drawdown zone reduces the aesthetic appeal of the area and prevents much recreational use of the reservoir.

1.06 Problems Related to Instream Flows - Flood control is a primary project purpose. The reservoir could be managed more effectively for flood control, as evidenced by observations that the current assumed downstream channel capacity (the maximum discharge that produces no flooding damage) could be increased without incurring flood damages.

1.07 Releases in the fall for pollution abatement (formerly to dilute sugar beet processing wastes in the Red River) are no longer needed. Minimum flows are needed to protect aquatic life in the Ottertail River, to dilute algae blooms in the Red River for aesthetic purposes, to

provide municipal water supply, and to allow recreational boating. The MDNR has recommended seasonal minimum and optimum instream flows to protect aquatic life that are generally greater during the summer months than the current releases. The MDNR has also recommended ramping (gradually changing) rates of release to prevent flushing and stranding of aquatic organisms.

1.08 Problems Related to Other Project Features - The low-flow conduits through the dam have valves that prevent good control of low-flow releases. The low-flow conduits exit into the stilling basin, with no provision for maintaining flow to the Ottertail River during dewatering for inspection of the stilling basin.

2.00 DESCRIPTION OF THE PROPOSED ACTION

Trial Period

2.01 A 5-year trial period of changed reservoir operation is proposed.

Reservoir Pool

2.02 The reservoir would be operated according to a new annual rule curve for pool elevation (alternative 2, ROPE report) that would greatly reduce the vertical range of pool fluctuations. Normal pool elevation is proposed to be 1,068 feet above mean sea level (ft msl) instead of the current 1,070 ft msl to minimize shoreline erosion.

Reservoir Releases

2.03 Downstream Channel Capacity - Preliminary observations indicate that controlled releases to 1,200 cubic feet per second (cfs) would not cause flood damages downstream. This rate of release would involve significantly greater flows than the previously assumed channel capacity of 900 cfs. Controlled releases of 1,200 cfs would be made during spring runoff in the trial period. Downstream effects would be

monitored to determine if any downstream flood damages occur or if the 1,200 cfs controlled release is acceptable.

2.04 Instream Flows for Aquatic Life, Pollution Abatement and Recreation - Instream flows for pollution abatement, recreational boating, and aquatic life would be maintained during the trial period by supplementing low flows as necessary. An attempt would be made to maintain optimal discharge rates as recommended by the MDNR (figure 37, ROPE report). If drought conditions occur, minimum instream flows to protect aquatic life in the Ottertail River would be maintained by augmenting flows from storage until the reservoir pool becomes unacceptably low. Changes in discharge rate would be ramped, or made gradual, as recommended by the MDNR (page 59, ROPE report) to prevent flushing or stranding of aquatic organisms.

Other Proposed Changes to Project Features

2.05 Modification of Low-Flow Conduits - New control valves for the low-flow conduits would be installed. Pipe connections to the low-flow conduits would be used to maintain minimum flows to the Ottertail River during future stilling basin inspections.

2.06 Subimpoundment - A 220-acre subimpoundment is proposed for the south arm of the reservoir. This subimpoundment would be created by replacing aging culverts in the County Highway 2 crossing with a new culvert and a stoplog control structure. This change would allow the subimpoundment to be operated independently of the main reservoir pool. The MDNR would operate the control structure and manage the subimpoundment area for waterfowl and other wildlife. Other subimpoundments around the periphery of the reservoir could be created by diking. Although the Corps does not plan to construct these smaller subimpoundments, the MDNR is encouraged to do so. Creation of these additional smaller subimpoundments would not jeopardize flood control operation of the reservoir. The smaller dike structures would prevent

peripheral wetland areas from draining as the main reservoir pool declines.

3.00 ALTERNATIVES

3.01 Alternatives considered with the proposed action include no action and alternative reservoir operating plans (see the ROPE report).

4.00 AFFECTED ENVIRONMENT

Environmental Setting

4.01 The Ottertail River above Orwell Reservoir drains a rolling glacial till plain with numerous lakes and marshes. The original vegetation was a mixture of hardwoods, savannah, wetland, bottomland hardwood, and prairie. Much of the land near the Orwell Reservoir is in agricultural use (Falk et al., 1975). Downstream of Orwell Reservoir, the Ottertail River flows through the flat glacial Lake Agassiz plain to Breckenridge, Minnesota, where it joins the Bois de Sioux River to form the Red River of the North.

Wildlife

4.02 The MDNR leases 1,957.6 acres of Federal land around the reservoir and actively manages the area for wildlife. The Orwell Wildlife Management Area includes 724 acres of grassland, 350 acres of wetlands, 652 acres of woods, 102 acres of low shrub and deciduous cover, 35 acres of annual food plots, and 45 acres of planted shelterbelts.

4.03 The MDNR observed 83 species of birds and 14 species of mammals in the Ottertail River valley during a recent survey (Hanson et al., 1984). Many additional wildlife species are known to be present (Hennings et al., 1980). White-tailed deer are the only big-game animal in the area. The project land is valuable wintering habitat for the deer. Ring-necked pheasants, Hungarian partridge, jack rabbit, and cottontail

rabbit are important small game species. Muskrat, beaver, mink, raccoon, skunk, river otter, red fox, and coyote are the furbearers that occur near Orwell Reservoir, although river otter and coyotes are rare. Mallards, wood ducks, Canada geese, and blue-wing teal use wetlands and islands around the reservoir for nesting, especially in the south arm. Numerous waterfowl species use the reservoir during migration. Nongame bird species of interest that may occur at the project include the bald eagle, osprey, white pelican, sandhill crane, American egret, double-crested cormorant, and common loon.

Aquatic Life

4.04 The 1,110-acre reservoir supports only a limited fish assemblage that is dominated by carp, buffalo, and bullheads. Some walleye, northern pike, and black crappie are present in low numbers. Aquatic life in the reservoir is very limited because of the fluctuating water levels that prevent establishment of stable littoral habitat. Dense algae blooms during the summer months further reduce the quality of aquatic habitat in the reservoir.

4.05 The Ottertail River upstream of Orwell Dam is free-flowing for less than a mile, to the Dayton Hollow Dam. This reach of river is shallow, with extensive riffle area. Downstream of Orwell Dam, the Ottertail River has successive riffles and pools, with rocks and woody debris for cover. This reach of the river supports walleyes, carp, redhorse, and suckers. A popular sport fishery for walleyes exists in the tailwaters below Orwell Dam.

Threatened and Endangered Species

4.06 The bald eagle and peregrine falcon are the only two federally-listed species that may occur in the project area. The only State-listed species that may occur at the project area is the western grebe. Nesting grebes were reported on the south arm of the reservoir in 1977, but fluctuating water levels prevented successful nesting in 1978. No

nesting by western grebes at Orwell Reservoir has been reported since that time.

Social and Economic Conditions

4.07 Although the urban area of Fargo-Moorhead is barely 50 miles from the Orwell site, the project area is thoroughly rural. The nearest city, Fergus Falls, had a 1980 population of 12,519. The reservoir is situated in a natural landform that also serves as a demographic dividing line. The higher, lake-dotted land to the east has more populous, industrial counties (Becker: 29,336; Douglas: 27,829; and Otter Tail: 51,937) that have been experiencing considerable growth (13 to 22 percent in the 1970's). The lower, western counties (Grant: 7,171; Stevens: 11,332; Traverse: 5,542; and Wilkin: 8,454) are almost entirely agricultural, with zero growth or considerable loss of population (4 to 11 percent decline in the 1970's).

4.08 Agriculture remains the economic base of the project area even though agricultural employment has dropped 8.3 percent from 1970 to 1980 (10,691 to 9,806). Total employment, on the other hand, increased over 27 percent during the same period (43,570 to 55,490), indicating a diversification of the employment structure. Manufacturing, trade, and service industries accounted for 84 percent of the increase in total employment. Real per capita income (1969 dollars) also increased, ranging from 19.5 percent for Stevens County ($2,399 to $2,867) to 48.1 percent for Wilkin County ($2,132 to $3,157).

4.09 Flooding of the Ottertail River results in economic damages to Breckenridge and the agricultural area between Orwell Dam and Breckenridge. Average annual damages at Breckenridge under existing conditions amount to $14,500, and 10,200 acres of agricultural land are flooded on an average annual basis.

Recreation Resources

4.10 Orwell Reservoir is in a scenic, partially wooded region with glacial hills and many lakes. The glacial Lake Agassiz lake plain to the west is flat and intensively farmed. Four State parks and numerous wildlife management areas are within 75 miles of Orwell Reservoir. The region provides many outdoor recreation opportunities, particularly for water-oriented activities. The lake district near Fergus Falls supports popular sport fisheries. The MDNR has identified the Ottertail River as a potential canoe trail. The interstate North Country Trail, now being developed, will extend through the Orwell Reservoir area.

4.11 Recreational demand in the region is somewhat high because of the lack of recreational opportunities available in the Fargo-Moorhead area, tourism promotion, and proximity to Interstate 94. Demand for hunting opportunities in this region is greater than the hunting demand in any other region in Minnesota. Many North Dakotans, especially from the Fargo area, travel to the Fergus Falls region for summer recreation activities. The popular recreation activities in the Orwell area include boating, fishing, swimming, camping, hiking, picnicking, driving for pleasure, bicycling, and hunting.

4.12 Recreation opportunities and facilities around the Orwell Reservoir are in short supply and of low quality. However, the city of Fergus Falls maintains 19 parks on 5 lakes that total 500 acres. Camping sites are somewhat limited in the area. The Orwell Reservoir project provides only day-use facilities for picnicking, fishing, and hunting. Little recreation activity besides hunting takes place on the reservoir pool. A popular tailwater fishery for walleye and northern pike exists in the Ottertail River below Orwell Dam.

4.13 Project features that limit recreational experience at the Orwell project mostly relate to reservoir operation. Large pool fluctuations have created an unsightly drawdown zone, have prevented development of a sport fishery, and have limited access to the reservoir. Summer storage

has reduced summer flows to the Ottertail River, thereby limiting canoeing opportunity and the aquatic habitat necessary to sustain a productive sport fishery. Other project features that could be improved include reservoir access, bank fishing access, signage, interpretive facilities, and primitive campsites.

Cultural Resources

4.14 Two cultural resources surveys have been undertaken at Orwell Reservoir. The first survey was a shoreline survey of the Orwell Reservoir foreshore that was completed in 1981. This survey located a burial mound group on the floodplain and three habitation sites in upland areas. At the time of the survey, one of the upland sites was in danger of eroding. Another survey was conducted during the 1985 field season. This survey was undertaken to investigate the impact of erosion on archeological resources. Sixteen erosion stations (consistent with Reid, 1983) were examined for cultural resources and for the impact to these resources from erosion induced by reservoir operation. The survey located three additional archeological sites, all along the south reservoir shore and all being affected by erosion. A preliminary analysis of the material recovered from these sites indicates that they may not qualify for a determination of eligibility for the National Register of Historic Places. However, it is likely that additional cultural resources in the reservoir area have not yet been identified.

5.00 ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION AND ALTERNATIVES

Terrestrial Impacts

5.01 The proposed changes in pool regulation would substantially reduce the rate of shoreline erosion and loss of terrestrial habitat. The eroding banks should stabilize in time and become vegetated. The erosion bench at the base of the cut banks, although occasionally inundated, should become vegetated with willow and other water-tolerant plants. This process may be accelerated by planting willow cuttings.

5.02 Some minor disturbance would occur during culvert and control structure placement at the County Highway 2 crossing and at the spillway on the dam during low-flow conduit repair. These areas have been previously disturbed and provide limited habitat value. All areas of disturbed ground would be reseeded following construction.

Aquatic Impacts

5.03 Within-Reservoir Impacts - Creation of a 220-acre subimpoundment in the south arm of the reservoir would stabilize water levels in an extensive littoral and wetland area, greatly enhancing habitat quality. The subimpoundment would have drawdown capability, so that drawdowns for rough fish control and vegetation management can be made. The subimpoundment area should soon become excellent habitat for waterfowl and other wetland wildlife.

5.04 The main body of the reservoir should improve under a revised operating regime with reduced pool fluctuations. If the drawdown zone can be limited to 4 feet or less, a stable littoral zone should form in a band around the reservoir shore and islands. This littoral zone with submersed vegetation would provide structural habitat for fish and substrate for benthic macroinvertebrates. Fish biomass in the reservoir should increase because of development of a littoral zone and improved spawning habitat. Current pool fluctuations probably prevent spawning by sunfishes, perch, and walleyes in the reservoir. Spawning success of these fishes in Orwell Reservoir should improve.

5.05 Water quality should gradually improve because of the reduced amounts of suspended solids that would originate from the eroding shoreline.

5.06 Increased spring releases to channel capacity (1,200 cfs rather than the present 900 cfs) would result in reduced height, frequency, and duration of flood surcharges in the reservoir. Reduction in flood

surcharges would maintain the Ottertail River below Dayton Hollow Dam in a more natural riverine condition, reduce shoreline erosion, and allow more colonization of the reservoir shoreline by water-tolerant vegetation.

Downstream Impacts

5.07 The proposed regulating plan would change the existing average annual hydrograph of the river by increasing summer releases (rather than storing water for fall release) and by providing higher minimum flows. Attempts to provide reservoir releases within seasonal optimum ranges recommended by the MDNR would enhance habitat and fish spawning success. Provision of adequate instream flows for aquatic life would also satisfy demands for water for recreational boating, downstream dilution of algae blooms, and municipal water supply.

5.08 Although flood storage capacity currently attained by winter drawdowns in the reservoir would be reduced because of lesser precautionary drawdowns, late-winter/early-spring drawdowns would be conducted if greater runoff events are anticipated. In addition, the increased controlled release to channel capacity would effectively provide additional flood storage capacity in the reservoir. Flood protection provided by Orwell Reservoir would, therefore, not be compromised by the revised operating plan.

Threatened and Endangered Species

5.09 The only federally-listed endangered species that may be affected by the proposed action is the bald eagle, which could benefit from increased biomass of fish in the reservoir and greater concentrations of waterfowl in the subimpoundment area. Creation of the subimpoundment would provide suitable habitat for the western grebe, the only State-listed species reported from the project area.

Social and Economic Effects

5.10 The recommended changes would have no significant effects on the following social and economic impact categories listed in Section 122 of the 1970 Rivers and Harbors Act: noise levels, community cohesion, community growth, business and home relocations, tax revenues, public facilities and services, and employment. Work on County Highway 2 would cause some short-term disruption in local transportation. Appearance of the shoreline will be improved. Negative social impacts would be minimized by the remote location of the reservoir, the agricultural nature of the downstream area, the Federal financing of the recommended changes, the testing of the channel capacity assumption conducted during 1985, and the trial period for the changes.

5.11 Implementation of alternative operating plan 2 would have economic benefits beyond those already realized by the existing Orwell Dam. Average annual flood control benefits at Breckenridge would increase by $6,900. Average annual agricultural flooding would be reduced by approximately 4,000 acres. The dollar equivalent of this reduction in agricultural flooding remains to be evaluated in a more advanced stage of the study.

Effects on Recreation

5.12 The proposed operation plan (alternative 2) would have a favorable effect on recreation opportunities at the Orwell Reservoir. This plan would allow more control by holding the drawdown until late spring and returning to normal level as quickly as possible. A stable pool elevation would allow development of shoreline recreation, such as boat launching. Improvement of aquatic habitat in the reservoir would enhance opportunities for recreational fishing. Increased summer releases to the Ottertail River would improve fishing opportunities below the dam and would benefit canoeing conditions downstream. The proposed subimpoundment should also attract more wildlife to the area, thereby improving wildlife observation and hunting opportunities. Most

of the project land is in the Orwell Wildlife Management Area. Recreation activities there must be compatible with the Minnesota Department of Natural Resources wildlife management efforts. The refuge area, for example, is closed to visitor entry during the waterfowl migration season in the fall.

5.13 The other reservoir operating alternatives considered would not provide improved recreation conditions for both the reservoir and the Ottertail River downstream. The rule curve for alternative 1, while appearing to result in a constant pool elevation, in fact, would result in higher and more frequent pool surcharge events than alternative 2 would. The long duration of these pool surcharge events would cause shoreline erosion and deterioration of riparian vegetation, thus detracting from the scenic character of the reservoir. Alternative 3 may result in greater pool level fluctuations and in longer durations of higher water levels. Alternative 3 would release stored water during the summer months in excess of normal stream flow. Alternatives 4 through 9 identify water level fluctuations in the reservoir that are too extreme to be considered for recreational development.

Effects on Cultural Resources

5.14 In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, the National Register of Historic Places has been consulted. As of January 1, 1986, no properties listed on or determined eligible for the National Register would be affected by the proposed actions.

5.15 Operation of the reservoir in a manner that would eliminate or reduce the wide fluctuations in the reservoir pool elevation would decrease the amount of erosion of the existing shoreline and therefore prevent further destruction of the cultural resources data base. Alternatives that achieve this goal are greatly preferable to continuing the present operating plan. Modification of the low-flow conduits and the replacement of the culverts in the County Highway 2 crossing with a

new culvert and stoplog control structure would not affect cultural resources.

Impacts of Alternative Actions

5.16 No Action - The no action alternative would continue the status quo condition described in section 4 above. Drawdowns of up to 27 feet would continue to be made, shoreline erosion would continue unabated, and fish and wildlife habitat associated with the reservoir would remain limited in many respects.

5.17 Alternative Operating Plans - Potential alternative reservoir operating plans are infinite and depend on the value placed on the various water-use demands, authorized purposes, hydrologic conditions, reservoir configuration, spillway capacity, and control factors that must be considered. Nine alternative rule curves for pool elevation and accompanying regulation schedules are presented in the ROPE study report, pages 67-85. A range of flood control drawdowns and summer releases for instream flows were compared to check sensitivity for providing flood control, fish and wildlife, recreation, and pollution abatement benefits. Alternative 1 (ROPE study report, pages 68-69), a year-round stable pool, would enhance recreation and fish and wildlife benefits at the expense of flood control. Alternative 2 (ROPE study report, pages 70-71) includes a normal pool elevation of 1068 ft msl to minimize shoreline erosion and a late winter drawdown of 4 feet. This alternative is the proposed operating schedule and should approach a maximum provision of project benefits. Monitoring of project performance during the proposed trial operation period and application of a computer model of reservoir operation should allow further refinement of the operating plan.

5.18 Alternative Water Control Structures - Alternative water control structures for the County Highway 2 culvert replacement that would form a subimpoundment were considered. The corrugated metal culvert with stoplogs in a standpipe would be the least costly and simplest

structure. Aluminum stoplogs would be used to prevent jamming. Screened stoplogs could be used by the MDNR for filling the subimpoundment from the main pool while excluding rough fish. The standpipe control structure would allow water control up to 1,074 ft msl, the top elevation of the highway crossing.

5.19 Alternatives for low-flow conduit valve replacement are limited to no action, new valves, or entirely new low-flow conduits. Two-foot diameter replacement valves would be used to pass sufficient flow and minimize construction disturbance.

5.20 Alternatives for maintaining flow to the Ottertail River during dewatering of the stilling basin for inspections are no action and a number of methods of extending or rerouting the low-flow conduits to exit downstream of the stilling basin. A least-cost alternative was tentatively selected that involves installing flanges on the exit ports in the stilling basin wall. Steel pipe would be attached to the flanges to extend the low-flow conduits downstream of the stilling basin.

6.00 STEPS THAT WILL BE TAKEN TO MINIMIZE POTENTIAL ADVERSE EFFECTS OF THE PROPOSED ACTION

6.01 Performance of the revised reservoir operating plan would be monitored for a 5-year trial period. A computer model is recommended to simulate optimal reservoir operation. Results of monitoring and computer modeling would be used to refine the reservoir operating plan, which would then be incorporated into the reservoir operating manual.

6.02 Soil areas disturbed during subimpoundment construction and low-flow conduit repair would be graded and reseeded following construction.

6.03 Several aspects of the reservoir operating plan proposed would minimize adverse effects of reservoir operation. Normal pool operation at 1,068 ft msl would reduce shoreline erosion. Reduced drawdown for flood control would allow some development of a littoral zone in the

reservoir. Increased summer discharges, minimum discharges, and ramping of releases would minimize adverse effects on aquatic life in the Ottertail River downstream of Orwell Dam.

7.00 COORDINATION WITH OTHERS

Cultural Resources

7.01 Cultural resources coordination of the Orwell ROPE has been conducted with the Minnesota State Historic Preservation Officer, the National Park Service, and the State Archeologist.

Federal Agencies

7.02 The U.S. Fish and Wildlife Service has already reviewed and provided favorable comments on the draft Orwell ROPE study report. The U.S. Fish and Wildlife Service also has been asked to provide comments on this assessment and on threatened and endangered species in the proposed work area, in accordance with the Fish and Wildlife Coordination Act and the Endangered Species Act. On-site coordination was conducted with representatives of the U.S. Fish and Wildlife Service.

7.03 Because installation of the new culvert and subimpoundment control structure at the County Highway 2 crossing would involve reconstruction of an existing fill to original dimensions, resulting in minimal water quality effects, no Section 404(b) Clean Water Act demonstration will be prepared for this project. The U.S. Environmental Protection Agency has been asked to review and provide comments on this environmental assessment, in accordance with the Clean Air Act.

State Agencies

7.04 Extensive coordination, including on-site meetings, was made with representatives of the Minnesota Department of Natural Resources. Staff

of the Division of Wildlife, particularly Mr. Gordon Nielsen, Area Wildlife Manager, and staff of the Ecological Services Section were instrumental in the development of the reservoir operating plan.

Public

7.05 A public notice and opportunity for comment on this draft assessment will be made. Public notice was made in October 1985 on the draft ROPE study report. No comments were received.

Letters of Coordination

7.06 Letters of coordination with various agencies are exhibits to this assessment.

LITERATURE CITED

Hanson, R., P. Rivard, N. Kirsch, and J. Enblom. 1984. Biological Survey of the Ottertail River. Minnesota Department of Natural Resources Special Publication No. 137. St. Paul, Minnesota. 101 pp.

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Hennings, K., J. Parker, and J. Hansen. 1980. Hubbel Pond Wildlife Management Area Master Plan, 1980-1989. Minnesota Department of Natural Resources. St. Paul, Minnesota. 49 pp.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

St. Paul Field Office, Habitat Resources
50 Park Square Court
400 Sibley Street
St. Paul, Minnesota 55101

December 12, 1985

Colonel Joseph Briggs
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custon House
St. Paul, Minnesota 55101-1479

Dear Colonel Briggs:

This provides U.S. Fish and Wildlife Service comments relative to the St. Paul District's October 1985 Public Notice NCSPD-PF/Orwell and draft ROPE (Reservoir Operation Plan Evaluation) Report for the Orwell Reservoir on the Otter Tail River near Fergus Falls, Minnesota.

Based on our review of the draft Report, we agree that Alternative 2 (Corps tentatively recommended alternative plan) would appear to be the most practical and appropriate operation plan for this dam and reservoir. It also appears that the Corps is attempting to incorporate, to the extent possible, the modifications suggested by the Minnesota Department of Natural Resources to enhance conditions for fish and wildlife within the reservoir and state wildlife management area. These modifications would involve stabilizing water level fluctuations, reducing shoreline erosion and reestablishing aquatic macrophytes within the reservoir. In addition, the tentatively recommended plan would include the creation of a subimpoundment on the south arm of the reservoir for waterfowl and other wildlife as well as provide adequate year-round releases (minimum instream flows) downstream of the dam to protect aquatic resources within the Otter Tail River.

We commend the efforts that have been undertaken by the St. Paul District to initiate and coordinate this important study so that the benefits obtained from the operation and use of this reservoir can be optimized, to the extent possible, in contributing to its flood control, water supply, fish and wildlife, water quality and other authorized purposes. We are hopeful that similar operating plan evaluations will be undertaken of other Corps reservoirs in the future.

Exhibit 1

Please keep us informed of the modified operating plan which is ultimately recommended and implemented by the Corps at this reservoir site.

Sincerely,

James L. Smith
Acting Field Office Supervisor

cc: MN DNR, St. Paul/Fergus Falls
MN PCA, Roseville
US EPA, Chicago

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

BOX 500 LAFAYETTE ROAD • ST. PAUL, MINNESOTA • 55146

DNR INFORMATION
(612) 296-6157

December 31, 1985

Colonel Joseph Briggs
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Dear Colonel Briggs:

Thank you for the opportunity to review and comment on the Orwell Reservoir Operation Plan Evaluation. The document provides a thorough review of a range of operating plans for the reservoir and identifies alternatives that could greatly improve fish and wildlife habitat and recreation opportunities within the reservoir and on the Otter Tail River downstream from the project site.

Main Reservoir

Alternative #2, the Corps of Engineer's recommended National Economic Development (NED) plan, is perhaps more realistic from a flood control standpoint than Alternative #1, the best of the 9 alternatives from a fish and wildlife standpoint. With some modification, Alternative #2 should be acceptable from a fish, wildlife, and erosion control perspective. The major problem with Alternative #2 is the extended period the reservoir would be lowered from 1068 to 1064 based on the proposed rule curve. The 1068 level should be resumed as soon as possible after the initial spring runoff, and maintained at that level. It is implicit in the document and was reaffirmed at a December 3, 1985 meeting with the Corps that efforts will be made to accomplish this rapid return to the 1068 elevation. It is also our understanding that the extent of the spring drawdown will be based on annual runoff predictions and will not necessarily require the full drawdown to 1064 each year.

Bank erosion, as it affects the shoreline of the reservoir (as discussed on page 100 and several other places in the document) and islands within the reservoir, is a serious problem. Stabilizing reservoir levels at 1068 would alleviate this problem. The Corps states on page 63 that the eroded bank faces of the reservoir would gradually (up to 15 years) attain a stable angle of repose and naturally revegetate. The Corps assumes costs of accelerating the bank stabilization to be high because shaping and seeding would be necessary. The use of rock riprap was eliminated from the project plan because of cost estimates exceeding $250,000. Future discussions between the Corps of Engineers and the DNR are strongly encouraged to pursue an active program to accelerate bank stabilization and revegetation with the appropriate native species. We feel accelerated bank stabilization would: enhance conditions for the establishment of a productive littoral zone within a more reasonable time frame, improve water quality within and downstream of the reservoir, and enhance the value of the islands for various wildlife species.

Exhibit 2

We encourage the initiation of a bank erosion study, using erosion stakes and photo stations, to monitor the current rate of bank erosion. Areas of severe bank erosion would receive first priority. As discussed at the December 10, 1985 meeting with Corps and DNR staff, further interagency discussion and coordination is recommended to define in more detail the nature of such a study and the level of DNR involvement regarding study implementation and/or data collection.

Instream Flow

Compared to existing operation, all nine alternative operation plans listed in the ROPE report will increase instream flow in the Otter Tail River below Orwell Reservoir by about 80 cfs, on the average, for the period July 15 through September 20. Under the existing operation plan, part of the inflow to Orwell Reservoir is stored during this period to raise the pool elevation to 1070. Increasing flow in the Otter Tail River downstream of Orwell Reservoir during the summer will increase available habitat for fish and wildlife resources during a critical period and should benefit recreational use of the river.

The "Regulation Schedule" on the page opposite the rule curve for each of the 9 alternatives contains a statement under "Operations" for Flood Control, Condition-Flood Protection that "Minimum discharge shall not be less than 40 cfs". Based on the text of the document this statement does not appear appropriate. To reduce downstream flooding during periods of high flow a portion of the inflow will be stored in the reservoir, but not to the extent that the outflow would be reduced to 40 cfs. Also, the text incorporates DNR's recommendations of a minimum release of 80 cfs for the whole year and considerably higher flows for spawning from late March through May. We recommend that the statement regarding the 40 cfs minimum discharge be deleted from the portion regarding Flood Control. The statement "Minimum discharge shall not be less than 80 cfs" should be added. This could be done with either a separate heading or by revising one of the existing headings to include a minimum for the whole year.

A portion of the description of "Operations" for summer and fall floods in each of the 9 alternatives needs to be clarified or restated. The statement is "...surcharge the pool by 90 percent of inflow..." This could be interpreted to mean store 90 percent of inflow and discharge the remaining 10 percent of inflow. It is our understanding that the intent of this statement is to surcharge the pool by discharging 90 percent of inflow and storing 10 percent.

On pages 106 and 107 of the plan there is a discussion of cost estimates for replacement of the low flow control valves. The existing low flow conduits discharge into the stilling basin and cannot be used during periodic routine inspections of the stilling basin which require dewatering. This section of the plan should also address extending the existing low flow conduits beyond the stilling basin or some other means of providing a continuous discharge to the river downstream of the dam during the routine inspections. This concern was listed in earlier DNR correspondence regarding the plan.

Use of reservoir storage to augment releases for instream flows during periods when inflow to the reservoir is less than 80 cfs was discussed at the December 3 and 10, 1985 meetings with Corps staff. DNR recommendations for instream flows included a year-round minimum release of 80 cfs. This recommendation was made with the understanding that there would be certain periods, such as during the 1976-77 drought, when it would not be possible to maintain the 80 cfs minimum release. The amount of storage in the reservoir is not adequate to maintain an 80 cfs minimum release during a prolonged period of low inflow to the reservoir. Operation during such periods should be clarified in the ROPE report.

We recommend the following procedure which is a combination of two alternatives discussed at the December 10, 1985 meeting.

When reservoir inflow is less than 80 cfs:

1. Maintain release of 80 cfs for the first 30 days of reservoir inflows less than 80 cfs.

2. Next 30 days of reservoir inflows less than 80 cfs: if reservoir inflow is between 70 and 80 cfs, continue release of 80 cfs. If reservoir inflow is less than 70 cfs, release the greater of (a) inflow plus 10 cfs from storage or (b) 50 cfs.

3. If reservoir inflow remains less than 80 cfs for 60 days, contact DNR for a coordination meeting and continue releases as per 2.

We will be conducting further time series analyses of flows and available habitat utilizing the IFIM-PHABSIM models. These modeling efforts may be useful in identifying additional operation alternatives during low flow periods.

South Arm Subimpoundment

Concerns about the adequacy of the watershed above the south arm subimpoundment site were discussed at the December 10, 1985 meeting with the Corps. The 25 square mile size of the watershed should be adequate (in most years) to achieve the desired water elevation for the subimpoundment. Also, under certain conditions it may be possible to fill the subimpoundment with water from the main reservoir through the south arm control structure.

Additional subimpoundment sites were identified through previous discussions and coordination with the Corps. We realize the Corps will not be constructing any of these additional subimpoundment structures as part of this project. We do, however, feel the final Orwell ROPE Report should reflect a willingness on the part of the Corps to permit the construction of the previously identified subimpoundment sites by nonfederal agencies. In this way these subimpoundments can be considered for future development.

Interagency Coordination

We encourage the continued coordination between the DNR and the Corps of Engineers. To facilitate this coordination we suggest that a tentative schedule outlining the chronology of the implementation of the Operations Plan be included in the final Orwell ROPE Report.

Finally, we feel the potential exists to increase or enhance fish, wildlife, and recreational resources at other Corps of Engineer reservoir sites in the state. Staff discussions between the DNR and the Corps of Engineers (December 10, 1985 meeting) indicated a willingness on the part of the Corps to examine other Reservoir Project Operation Plans. We would strongly encourage this and would appreciate the opportunity to participate in a similar way to that of our involvement with Orwell Dam.

Thank you for the opportunity to provide comments on this report. If you have any questions, please contact Joseph Gibson, Federal Projects Coordination at 296-2773.

Sincerely,

DIVISION OF WATERS

Larry Seymour
Director

LS/JCG:sr
cc: Larry Shannon
Commissioner Alexander
Gerald Paul
Tom Kalitowski
Terry Lejcher
West Ottertail SWCD

MINNESOTA
500 LAFAYETTE ROAD ST. PAUL, MINNESOTA
TELECOPIER
(612) 296-5757

January 9, 1986

Wayne Knott
Army Corps of Engineers
1135 U. S. Post Office/Customs House
St. Paul, Minnesota 55101

Dear Mr. Knott:

In response to a January 2, 1986 telephone request from the Corps of Engineers, the Natural Heritage Program[1] has reviewed the Orwell reservoir project area (Corps Draft ROPE report October 1985) for occurrences of rare and/or sensitive species or natural features. A search of our database indicates that an active western grebe nesting site, was reported on the south side of the reservoir in 1977 (S 1/2 Sec 25 T132N R44W). Following drawdown of water levels nesting at this site failed (1978), and no nesting has been reported since that time.

The Division of Fish and Wildlife concerns about the new proposal were included in a DNR memo from Larry Seymour to Col. Briggs, 31 December 1985. Reduced water level fluctuations and improved timing of water level manipulation would probably improve conditions for potential western grebe nesting.

Sincerely,

Carmen K. Converse

CARMEN K. CONVERSE
Botanist/Data Manager
Natural Heritage Program

CKC:rcm

[1] The Natural Heritage Program, a unit within the Section of Wildlife, Department of Natural Resources, has compiled the most complete single source of existing data on Minnesota's rare, endangered, or otherwise significant plant and animal species, plant communities, and other natural features.

FINAL ORWELL ROPE REPORT

(RESERVOIR OPERATION PLAN EVALUATION)

CORRESPONDENCE APPENDIX

FINAL ORWELL ROPE REPORT
(RESERVOIR OPERATION PLAN EVALUATION)

CORRESPONDENCE APPENDIX

LETTERS WITHOUT CORPS RESPONSE

LAND OF QUALITY FOODS

STATE OF MINNESOTA
DEPARTMENT OF AGRICULTURE

90 W. PLATO BOULEVARD
SAINT PAUL, MN 55107
Telephone: (612) 296-1488

January 9, 1985

District Engineer
Attn: Herb Nelson (NCSPD-PF/Orwell)
St. Paul District, Corp of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101-1479

Dear Mr. Nelson:

I'm sorry it has taken me so long to reply to your request for comments on the Orwell Dam and Reservoir Study. As I indicated in our telephone conservation, I believe the main concerns the Minnesota Department of Agriculture would have would be related to protecting agricultural land from encroachment by the project, the protection of agricultural land from flooding, any soil erosion caused by management of the project, and perhaps any impact proposed management practices would have on area irrigation.

Please let me know if I can be of further assistance.

Yours truly,

MINNESOTA DEPARTMENT OF AGRICULTURE

Paul Burns

Paul Burns
Environmental Review Coordinator
Planning Division

PB:dw

AD-A167 896 FINAL ORWELL ROPE (RESERVOIR OPERATION PLAN EVALUATION) 3/3
REPORT AND ENVIRONMENTAL ASSESSMENT(U) CORPS OF
ENGINEERS ST PAUL MN ST PAUL DISTRICT JAN 86

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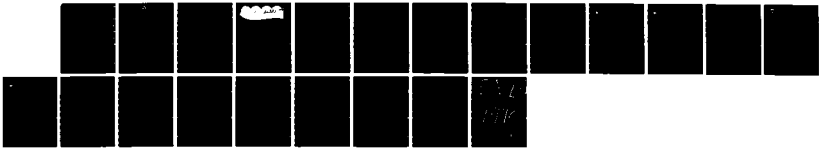

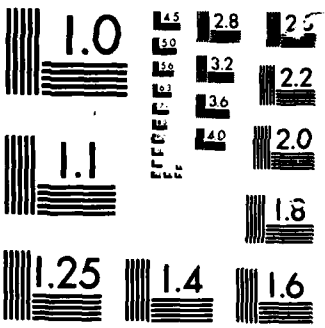

MICROCOPY CHART

CITY OF FARGO

NORTH DAKOTA

WATER
DEPARTMENT

KENNETH RUBY
SUPERINTENDENT

January 11, 1985

Herb Nelson
U.S. Corps of Engineers
St. Paul District
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101-1479

Attn: NCSPD-PF/Orwell

Dear Mr. Nelson:

The City of Fargo is vitally concerned with the operation of Orwell Dam and Reservoir, both for water supply and pollution control.

In the past the plan of operation has worked very well in providing a water supply to the City of Fargo. I would not like to see it altered materially for that purpose. However summer operation still should consider pollution abatement.

Fargo's NPDES Permit sets limits on Biochemical Oxygen Demand, Suspended Solids, pH and Coliform Bacteria in the effluent from the Sewage Treatment Plant. It also sets limits on the total pounds of B.O.D. that can be discharged per day. The pounds of B.O.D. vary according to the flow in the Red River. To date this limitation has never been a problem since the quality of our effluent has always been well below the standards permitted.

There could be a future problem however with ammonia. There is no ammonia limitation in our Discharge Permit at the present time, however, I believe there will be one in the future.

The past summer the North Dakota State Health Department required the City to monitor ammonia in the discharge from the treatment plant and in the river above its discharge point and the river below its discharge point. They then limited the quantity of our discharge per day based on the ammonia analyses, pH, temperature and the flow of the river.

The City of Fargo has a secondary trickling filter plant followed by six-90 acre waste stabalization ponds. The City's discharge permit doesn't allow any discharge under ice cover in the river. Therefore, the City can only discharge in the warmer months and store the sewage all winter.

The past summer the City's discharge was seriously limited due to the low flow in the river, particularly in August when the flow was under 100 cfs. We had no problem with B.O.D. or suspended solids but we did have a problem with the ammonia. The Health Department was afraid of a fish kill in the river if the ammonia content in the river got too high.

I hope that you will consider the above comments when evaluating any new plan for operation of Orwell Dam and Reservoir.

Sincerely yours,

Kenneth Ruby

Kenneth Ruby, Director
of Utilities

WAHPETON

PHONE (701) 642-8418

CITY HALL
WAHPETON, NORTH DAKOTA 58075

January 15, 1985

District Engineer
ATTN: NCSPD-PF/Orwell
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

Dear Sir;

The City of Wahpeton has received notice of the study to re-evaluate the operation of Orwell Dam in Minnesota. We are concerned about the operation of the dam as it does affect our city during flood time and also during low water periods in the summer months.

Please include the City of Wahpeton on your list of notices concerning any activities on the study and all proposed changes. If you have a current operation plan of Orwell Dam we would appreciate a copy of it also.

Thank you and should you require any information from us please feel free to contact me at any time.

Yours truly,

Jerry C. Lein
City Engineer

JCL/dm
CC: City Council

DEPARTMENT MDNR-Div. of Waters-Box 32

TO : Gary Palesh
Corps of Engineers

DATE: February 15, 1985

FROM : Joe Gibson Joe
Federal Projects Coordinator

PHONE: 296-2773

SUBJECT: ORWELL RESERVOIR - ROPE

Attached is a memo containing the comments that I have received regarding the reevaluation of the Orwell Reservoir operating plan. If you have additional questions, please contact me.

JCG:sr
Attachment

J-1

SF-00006-02

STATE OF MINNESOTA

Office Memorandum

DEPARTMENT NATURAL RESOURCES
Fish and Wildlife

TO : Joe Gibson
Division of Waters

RECEIVED
FEB 6 1985
Division of Waters

DATE: February 4, 1985

FROM : Larry R. Shannon, Director
Division of Fish and Wildlife

PHONE: 297-1308

SUBJECT: Orwell Reservoir - Corps ROPE Study

Attached is an outline of problems, planning constraints, and opportunities which the Division of Fish and Wildlife would like to have incorporated into the Corps ROPE (Reservoir Operating Plan Evaluation) Study for the Orwell Reservoir. This response was developed by Ecological Services staff in coordination with Regional and Area Fisheries and Wildlife personnel.

The Orwell WMA contains some excellent wildlife habitat and has value as a production area as well as a migration and wintering area. Care must be taken so that "improvements" to the Operating Plan do not result in more harm than good to these resources. Related to this is the fact that the waterfowl refuge currently harbors thousands of ducks and geese during fall migration. Nothing should change in the operation of the reservoir which would reduce the value of the refuge.

It is our feeling that providing wildlife habitat in the reservoir and adjacent areas and providing adequate downstream flows for fisheries should be the primary concern of the Reservoir Operating Plan. Any improvements that are made in the main pool area such as reducing water level fluctuations, optimizing water levels in the reservoir, bank stabilization, etc. will benefit both fisheries and wildlife. There is currently some good fish habitat in the upper reaches of the reservoir (below Dayton Hollow Dam) and in the tailwaters of the Orwell Dam and these two areas should be maintained or enhanced as fish habitat.

We feel, in conjunction with an improved Reservoir Operating Plan, that the most practical method for improving waterfowl and wildlife production of the WMA would be to subimpound various sites both on the south flowage area and on areas immediately adjacent to the main pool. Control structures should be designed that would provide permanent, stable wetlands (with drawdown capacity) and would also control rough fish movement into these areas. Based on our limited knowledge, we would assume that such structures would not seriously detract from the flood storage potential of the reservoir.

We are aware that periodic routine inspection of the stilling basin is needed and that such inspections require dewatering of the stilling basin. The existing low flow conduits discharge into the stilling basin and cannot be used during inspection. Some means of providing a continuous discharge to the river downstream of the dam during the routine inspections should be addressed in the ROPE Study.

Any specific operational features are difficult to specify without additional information. Specifically, we would require a topographic map of the reservoir, preferrably in 1 or 2 foot intervals, reservoir level and flow data for a series of years similar to the curve already provided, and a copy of the erosion control study conducted by John Reid at North Dakota State University.

Besides changes in the operation plan, there are other features of the reservoir and WMA which could be improved. These include fencing, access sites and parking lots, road improvements, vegetation management on the islands, and water control capability for the Type 4 wetland which straddles sections 35 and 36 just north of Highway 2. The ROPE study may be a good place to address some of these improvements.

We have recently received copies of four draft objective statements and follow-up narratives for the Problem Appraisal Report for Orwell Reservoir. We are encouraged by the draft objective statements and information contained in the narratives. We suggest that the Corps modify and/or expand the objective statements and narratives based on the information we are providing in the correspondence. We would like to review and comment on the revised draft prior to incorporation into the Problem Appraisal Report. Specifically, we would recommend that the objective dealing with fish and sport fishery enhancement in the main reservoir be modified to address wildlife concerns in the reservoir. Wildlife management continues to be our highest priority on this site.

We appreciate the efforts that the Corps has made to solicit inputs from the Division of Fish and Wildlife during this early stage of planning and look forward to continued cooperation as the project proceeds.

LRS:DS:db

cc: Larry Seymour
Richard Hassinger
Roger Holmes
Jack Skrypek
Robert Farms
Stan Daley
Gordy Nielsen
Don Reedstrom
Earl Huber
Joe Geis
Jack Enblom
Dave Schad

ORWELL ROPE STUDY

Problems

1. Reservoir

   A. Summer fluctuations

      a. Fish spawning hindered/fry-fingerling survival impacted
      b. Precludes establishment of aquatic plants and invertabrate populations
      c. Contributes to bank erosion which leads to turbidity and wind erosion problems.

   B. Winter drawdowns

      a. Contribute to bank erosion
      b. Aquatic habitat reduction and potential for winterkill
      c. Destroys littoral zone

   C. Extended high maximum reservoir level

      a. Contributes to bank erosion, increased turbidity, and siltation
      b. Precludes optimum littoral zone production

2. South arm and other shallow extensions of reservoir

   A. Summer fluctuations

      a. Floods waterfowl nests (overwater and upland)
      b. Floods nests of upland game birds (prairie chicken, pheasant and hungarian partridge) and non-game species
      c. Reduces quality of upland habitat
      d. Strands waterfowl broods
      e. Harms furbearer production and survival
      f. Fish spawning and fry/fingerling survival hindered

   B. Winter drawdowns

      a. Freeze out or strand furbearers
      b. Eliminates water important for spring waterfowl courtship activities

   C. High maximum reservoir level

      a. Wetland areas inundated
      b. Precludes establishment of aquatic plants and invertebrate populations
      c. Allows rough fish access from main Reservoir

3. Downstream of Reservoir

   A. High flows

      a. Impacts on fish spawning and fry/fingerling survival
      b. Impacts on available habitat for juveniles and adults
      c. Bank erosion

   B. Low flows

      a. Impacts on fish spawning and fry/fingerling survival
      b. Impacts on available habitat for juveniles and adults

c. Reduces value for aquatic recreation
d. Impacts bank denning furbearers
e. Impacts on invertebrate production

C. Rapid change in discharge

a. Stranding of fish and invertebrates
b. Impacts on fish spawning and fry/fingerling survival
c. Impacts on available habitat for juveniles and adults
d. Impacts on invertebrate production
e. Can contribute to bank erosion

Planning Constraints

1. Flow regime for downstream fisheries (to be determined from instream flow study)
2. Presence of roughfish in reservoir
3. Continued use of reservoir for flood control
4. Maintenance of value of waterfowl sanctuary and wildlife management area
5. Hydrologic constraints (evapotranspiration, inflow to reservoir, operation of upstream structures)

Opportunities

1. Stabilize pool in summer
2. Lower maximum pool level
3. Raise minimum pool level
4. Decrease duration of maximum pool
5. Subimpound sites off of reservoir
6. Stabilize banks (shore and islands)
7. Establish appropriate flow regime
8. Slow down rate of reservoir level fluctuations
9. Minimize rate of change in discharge

United States Department of the Interior

FISH AND WILDLIFE SERVICE
St. Paul Field Office, Ecological Services
570 Naipak Building
333 Sibley Street
St. Paul, Minnesota 55101

IN REPLY REFER TO:

March 26, 1985

Colonel Edward G. Rapp
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

Dear Colonel Rapp:

This provides U.S. Fish and Wildlife Service comments on your March 1985 Public Notice (NCSPD-PF) and Problem Appraisal Report concerning the operation and condition of the Orwell Dam and reservoir on the Otter Tail River southwest of Fergus Falls in Otter Tail County, Minnesota.

We believe that the Problem Appraisal Report addressed most of the concerns and operating plan modifications which have been expressed and/or recommended by the Minnesota Department of Natural Resources. We fully concur with and support the recommendations made by the Minnesota Department of Natural Resources in their February 4, 1985 memorandum which is included in the Correspondence Appendix of the Report. We also agree that environmental considerations will play an important part in determining which of the various potential project features identified on page 43 of the Report will ultimately be selected and implemented for this dam and reservoir. In our view, the Orwell Wildlife Management Area is a significant resource and, as such, the U.S. Fish and Wildlife Service would object to any proposed modification(s) which would have more than a minimal adverse impact on this important wildlife area.

We appreciate the opportunity to provide you with our early coordination comments ~~and~~ regarding this important study.

Sincerely,

James L. Smith
Acting Field Office Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

St. Paul Field Office, Habitat Resources
50 Park Square Court
400 Sibley Street
St. Paul, Minnesota 55101

December 12, 1985

Colonel Joseph Briggs
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custon House
St. Paul, Minnesota 55101-1479

Dear Colonel Briggs:

This provides U.S. Fish and Wildlife Service comments relative to the St. Paul District's October 1985 Public Notice NCSPD-PF/Orwell and draft ROPE (Reservoir Operation Plan Evaluation) Report for the Orwell Reservoir on the Otter Tail River near Fergus Falls, Minnesota.

Based on our review of the draft Report, we agree that Alternative 2 (Corps tentatively recommended alternative plan) would appear to be the most practical and appropriate operation plan for this dam and reservoir. It also appears that the Corps is attempting to incorporate, to the extent possible, the modifications suggested by the Minnesota Department of Natural Resources to enhance conditions for fish and wildlife within the reservoir and state wildlife management area. These modifications would involve stabilizing water level fluctuations, reducing shoreline erosion and reestablishing aquatic macrophytes within the reservoir. In addition, the tentatively recommended plan would include the creation of a subimpoundment on the south arm of the reservoir for waterfowl and other wildlife as well as provide adequate year-round releases (minimum instream flows) downstream of the dam to protect aquatic resources within the Otter Tail River.

We commend the efforts that have been undertaken by the St. Paul District to initiate and coordinate this important study so that the benefits obtained from the operation and use of this reservoir can be optimized, to the extent possible, in contributing to its flood control, water supply, fish and wildlife, water quality and other authorized purposes. We are hopeful that similar operating plan evaluations will be undertaken of other Corps reservoirs in the future.

Please keep us informed of the modified operating plan which is ultimately recommended and implemented by the Corps at this reservoir site.

Sincerely,

James L. Smith
Acting Field Office Supervisor

cc: MN DNR, St. Paul/Fergus Falls
MN PCA, Roseville
US EPA, Chicago

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

BOX , 500 LAFAYETTE ROAD • ST. PAUL, MINNESOTA • 55146

DNR INFORMATION
(612) 296-6157

January 9, 1986

Wayne Knott
Army Corps of Engineers
1135 U. S. Post Office/Customs House
St. Paul, Minnesota 55101

Dear Mr. Knott:

In response to a January 2, 1986 telephone request from the Corps of Engineers, the Natural Heritage Program[1] has reviewed the Orwell reservoir project area (Corps Draft ROPE report October 1985) for occurrences of rare and/or sensitive species or natural features. A search of our database indicates that an active western grebe nesting site, was reported on the south side of the reservoir in 1977 (S 1/2 Sec 25 T132N R44W). Following drawdown of water levels nesting at this site failed (1978), and no nesting has been reported since that time.

The Division of Fish and Wildlife concerns about the new proposal were included in a DNR memo from Larry Seymour to Col. Briggs, 31 December 1985. Reduced water level fluctuations and improved timing of water level manipulation would probably improve conditions for potential western grebe nesting.

Sincerely,

Carmen K. Converse

CARMEN K. CONVERSE
Botanist/Data Manager
Natural Heritage Program

CKC:rcm

[1] The Natural Heritage Program, a unit within the Section of Wildlife, Department of Natural Resources, has compiled the most complete single source of existing data on Minnesota's rare, endangered, or otherwise significant plant and animal species, plant communities, and other natural features.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

Park Square Court, Suite 50
400 Sibley Street
St. Paul, Minnesota 55101

January 31, 1986

Mr. Wayne A. Knott
Chief, Environmental Resources Branch
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

Dear Mr. Knott:

This responds to your January 27, 1986 letter requesting our comments on the Environmental Assessment (EA) prepared by the St. Paul District relative to the operational improvements which are being proposed for the Orwell Reservoir in Otter Tail County, Minnesota and the potential impacts of these improvements on federally listed threatened or endangered species and/or other fish and wildlife resources.

Based on our review of the EA and other information provided, we do not anticipate that the proposed improvements should have more than a minimal and temporary adverse affect on the fish and wildlife resources in this area. As indicated in our December 12, 1985 letter, we believe that the proposed improvements should greatly enhance conditions for fish and wildlife both within the reservoir and downstream of the dam within the Otter Tail River. We recommend, however, that the modifications suggested by the Minnesota Department of Natural Resources in their letter of December 31, 1985 which was attached to the EA be adequately addressed in the final Orwell ROPE Report.

Otter Tail County is within the breeding range of the bald eagle, a federally listed threatened species. However, because of the location of this reservoir and the kind of improvements proposed, the proposed actions will not affect the bald eagle or any other federally listed threatened or endangered species or their critical habitat. This precludes the need for further action on this proposal as required under Section 7 of the Endangered Species Act of 1973, as amended. However, if new information becomes available which indicates that listed species may be affected, consultation with this office should be reinitiated.

We appreciate the opportunity to provide our comments with respect to these proposed improvements. These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the National Environmental Policy Act and the Fish and Wildlife Service's Mitigation Policy. This proposal was also examined for its conformance with the Endangered Species Act of 1973, as amended and Executive Orders 11988 and 11990.

Sincerely,

James L. Smith
Acting Field Office Supervisor

cc: MN DNR, St. Paul

LETTER WITH CORPS RESPONSE

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

BOX . 500 LAFAYETTE ROAD • ST. PAUL, MINNESOTA • 55146

DNR INFORMATION
(612) 296-6157

December 31, 1985

Colonel Joseph Briggs
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Dear Colonel Briggs:

Thank you for the opportunity to review and comment on the Orwell Reservoir Operation Plan Evaluation. The document provides a thorough review of a range of operating plans for the reservoir and identifies alternatives that could greatly improve fish and wildlife habitat and recreation opportunities within the reservoir and on the Otter Tail River downstream from the project site.

Main Reservoir

Alternative #2, the Corps of Engineer's recommended National Economic Development (NED) plan, is perhaps more realistic from a flood control standpoint than Alternative #1, the best of the 9 alternatives from a fish and wildlife standpoint. With some modification, Alternative #2 should be acceptable from a fish, wildlife, and erosion control perspective. The major
1. problem with Alternative #2 is the extended period the reservoir would be lowered from 1068 to 1064 based on the proposed rule curve. The 1068 level should be resumed as soon as possible after the initial spring runoff, and maintained at that level. It is implicit in the document and was reaffirmed at a December 3, 1985 meeting with the Corps that efforts will be made to accomplish this rapid return to the 1068 elevation. It is also our understanding that the extent of the spring drawdown will be based on annual runoff predictions and will not necessarily require the full drawdown to 1064 each year.

Bank erosion, as it affects the shoreline of the reservoir (as discussed on page 100 and several other places in the document) and islands within the reservoir, is a serious problem. Stabilizing reservoir levels at 1068 would alleviate this problem. The Corps states on page 63 that the eroded bank faces of the reservoir would gradually (up to 15 years) attain a stable angle of repose and naturally revegetate. The Corps assumes costs of accelerating the bank stabilization to be high because shaping and seeding would be necessary. The use of rock riprap was eliminated from the project plan because of cost estimates exceeding $250,000. Future discussions between the Corps of Engineers
2. and the DNR are strongly encouraged to pursue an active program to accelerate bank stabilization and revegetation with the appropriate native species. We feel accelerated bank stabilization would: enhance conditions for the establishment of a productive littoral zone within a more reasonable time frame, improve water quality within and downstream of the reservoir, and enhance the value of the islands for various wildlife species.

AN EQUAL OPPORTUNITY EMPLOYER

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ST. PAUL DISTRICT RESPONSE TO DNR COMMENTS

1. The rule curve and description of alternative 2 on pages 68 and 69 of the draft ROPE report are misleading. The intent of alternative 2 is that the drawdown should be minimized and delayed as much would be allowed by prevailing hydrologic conditions. Figures 26 and 27 on pages 109 and 110 of the draft ROPE report reflect the intended operation better than the operation statements on page 69 do. The description on page 69 has been clarified, and the diagram on page 68 has been modified to better reflect the intended operation, as described on pages 109 and 110 of the draft ROPE report. See pages 70, 71, 111, and 112 of this final report.

2. The District has been in contact with the Corps Waterways Experiment Station and others to identify plant species and planting methods to be used in attempts to revegetate the eroding banks. The revegetation effort is further described under the Implementation Activities section of this final ROPE report.

3. We encourage the initiation of a bank erosion study, using erosion stakes and photo stations, to monitor the current rate of bank erosion. Areas of severe bank erosion would receive first priority. As discussed at the December 10, 1985 meeting with Corps and DNR staff, further interagency discussion and coordination is recommended to define in more detail the nature of such a study and the level of DNR involvement regarding study implementation and/or data collection.

Instream Flow

Compared to existing operation, all nine alternative operation plans listed in the ROPE report will increase instream flow in the Otter Tail River below Orwell Reservoir by about 80 cfs, on the average, for the period July 15 through September 20. Under the existing operation plan, part of the inflow to Orwell Reservoir is stored during this period to raise the pool elevation to 1070. Increasing flow in the Otter Tail River downstream of Orwell Reservoir during the summer will increase available habitat for fish and wildlife resources during a critical period and should benefit recreational use of the river.

The "Regulation Schedule" on the page opposite the rule curve for each of the 9 alternatives contains a statement under "Operations" for Flood Control, Condition-Flood Protection that "Minimum discharge shall not be less than 40 cfs". Based on the text of the document this statement does not appear appropriate. To reduce downstream flooding during periods of high flow a portion of the inflow will be stored in the reservoir, but not to the extent that the outflow would be reduced to 40 cfs. Also, the text incorporates DNR's recommendations of a minimum release of 80 cfs for the whole year and considerably higher flows for spawning from late March through May. We

4. recommend that the statement regarding the 40 cfs minimum discharge be deleted from the portion regarding Flood Control. The statement "Minimum discharge shall not be less than 80 cfs" should be added. This could be done with either a separate heading or by revising one of the existing headings to include a minimum for the whole year.

5. A portion of the description of "Operations" for summer and fall floods in each of the 9 alternatives needs to be clarified or restated. The statement is "...surcharge the pool by 90 percent of inflow..." This could be interpreted to mean store 90 percent of inflow and discharge the remaining 10 percent of inflow. It is our understanding that the intent of this statement is to surcharge the pool by discharging 90 percent of inflow and storing 10 percent.

On pages 106 and 107 of the plan there is a discussion of cost estimates for replacement of the low flow control valves. The existing low flow conduits discharge into the stilling basin and cannot be used during periodic routine inspections of the stilling basin which require dewatering. This section of the

6. plan should also address extending the existing low flow conduits beyond the stilling basin or some other means of providing a continuous discharge to the river downstream of the dam during the routine inspections. This concern was listed in earlier DNR correspondence regarding the plan.

3. A detailed study of physical processes of bank erosion and recession rates at Orwell Reservoir (Reid, 1984) was conducted under contract for the Corps. An extensive erosion monitoring effort, as described in the MDNR comment letter, is beyond the scope of this ROPE effort, particularly in light of current fiscal restraints. Photo stations will be established to monitor the most active erosion sites and revegetation efforts. Revegetation of the eroding banks will be attempted, as discussed in our response number 2.

4. The MDNR provided the information on pages 68-83 concerning instream flow requirements and low-flow conditions in response to requests from the St. Paul District in the problem appraisal report and during a coordination meeting on August 9, 1985. These recommendations by the MDNR are incorporated into alternative 2, the selected plan, to the greatest extent possible. The statement about the 40 cfs minimum discharge has been deleted. See also our response to comment 7.

5. The wording has been changed to read ". . .surcharge the pool by releasing 90 percent of inflow. . . ."

6. These items are described in the Description of Recommended Operation Plan section of the report. Because this information was not complete at the time of the draft report, it was intentionally omitted from the draft. Development of these subimpoundment sites by the MDNR or others is encouraged by the St. Paul District.

Use of reservoir storage to augment releases for instream flows during periods when inflow to the reservoir is less than 80 cfs was discussed at the December 3 and 10, 1985 meetings with Corps staff. DNR recommendations for instream flows included a year-round minimum release of 80 cfs. This recommendation was made with the understanding that there would be certain periods, such as during the 1976-77 drought, when it would not be possible to maintain the 80 cfs minimum release. The amount of storage in the reservoir is not adequate to maintain an 80 cfs minimum release during a prolonged period of low inflow to the reservoir. Operation during such periods should be clarified in the ROPE report.

7. We recommend the following procedure which is a combination of two alternatives discussed at the December 10, 1985 meeting.

When reservoir inflow is less than 80 cfs:

1. Maintain release of 80 cfs for the first 30 days of reservoir inflows less than 80 cfs.

2. Next 30 days of reservoir inflows less than 80 cfs: if reservoir inflow is between 70 and 80 cfs, continue release of 80 cfs. If reservoir inflow is less than 70 cfs, release the greater of (a) inflow plus 10 cfs from storage or (b) 50 cfs.

3. If reservoir inflow remains less than 80 cfs for 60 days, contact DNR for a coordination meeting and continue releases as per 2.

We will be conducting further time series analyses of flows and available habitat utilizing the IFIM-PHABSIM models. These modeling efforts may be useful in identifying additional operation alternatives during low flow periods.

South Arm Subimpoundment

Concerns about the adequacy of the watershed above the south arm subimpoundment site were discussed at the December 10, 1985 meeting with the Corps. The 25 square mile size of the watershed should be adequate (in most years) to achieve the desired water elevation for the subimpoundment. Also, under certain conditions it may be possible to fill the subimpoundment with water from the main reservoir through the south arm control structure.

8. Additional subimpoundment sites were identified through previous discussions and coordination with the Corps. We realize the Corps will not be constructing any of these additional subimpoundment structures as part of this project. We do, however, feel the final Orwell ROPE Report should reflect a willingness on the part of the Corps to permit the construction of the previously identified subimpoundment sites by nonfederal agencies. In this way these subimpoundments can be considered for future development.

7. These low-flow rules will be incorporated into the operation plan. An additional constraint concerning pool elevation has been added by the St. Paul District to each of these three low-flow rules. If the pool drops below elevation 1060, then the discharge would equal the inflow. In this case, the release rate would be gradually ramped down from 80 cfs to the inflow over a 1-week period.

8. The additional subimpoundment sites will not be implemented by the Federal Government in the foreseeable future. The sites are appropriate for non-Federal development and would not significantly reduce the flood control benefit of the project if the tops of the control berms are maintained below elevation 1074.

Interagency Coordination

We encourage the continued coordination between the DNR and the Corps of Engineers. To facilitate this coordination we suggest that a tentative schedule outlining the chronology of the implementation of the Operations Plan be
9. included in the final Orwell ROPE Report.

Finally, we feel the potential exists to increase or enhance fish, wildlife, and
10. recreational resources at other Corps of Engineer reservoir sites in the state. Staff discussions between the DNR and the Corps of Engineers (December 10, 1985 meeting) indicated a willingness on the part of the Corps to examine other Reservoir Project Operation Plans. We would strongly encourage this and would appreciate the opportunity to participate in a similar way to that of our involvement with Orwell Dam.

Thank you for the opportunity to provide comments on this report. If you have any questions, please contact Joseph Gibson, Federal Projects Coordination at 296-2773.

Sincerely,

DIVISION OF WATERS

Larry Seymour
Director

LS/JCG:sr
cc: Larry Shannon
Commissioner Alexander
Gerald Paul
Tom Kalitowski
Terry Lejcher
West Ottertail SWCD

9. The implementation schedule is included in the Implementation Activities section of the report starting on page 129.

10. Consideration will be given to doing ROPE studies at other St. Paul District reservoirs. The evaluations will be prioritized and entered into the budgetary process, as appropriate. The funding for these activities is subject to competition with other projects and to national fiscal constraints.

CORPS OF ENGINEERS DISTRIBUTION ONLY

IMPLEMENTATION COST ESTIMATE

Fiscal Year 1985	
ROPE Report	$188,000
Fiscal Year 1986	
Input Hydrologic Period of Record to Computer Data Base	$ 6,000
HEC-5 Model Labor and Computer Cost	35,000
Water Quality Modeling	25,000
Plan Formulation Refinement PD-PF	7,000
Economic Refinement	4,000
Hydrologic Monitoring	3,000
Public Coordination	5,000
Project Management ED-M	10,000
Total FY 1986	$95,000
Fiscal Year 1987	
Hydrologic Monitoring	$ 3,000
Coordination	2,000
Project Management	1,000
Total FY 1987	6,000
Fiscal Year 1988	
Hydrologic Monitoring	3,000
Coordination	2,000
Project Management	1,000
Total FY 1988	6,000
Fiscal Year 1989	
Update Reservoir Regulation Manual	40,000
Total FY 1989	40,000
TOTAL FY 1985 TO FY 1989	$370,000

END

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